THE USE OF COST-BENEFIT ANALYSIS FOR EVALUATING FORESTRY PLANTATION DEVELOPMENT PROGRAMMES WITH PARTICULAR REFERENCE TO THE BOWENIA PLANTATION AT BYFIELD

by

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Originality of the thesis

Except where specific acknowledgement is given, this thesis is my own original work.

Sar Ngomley

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SUMMARY

In many of the less developed countries, the improvement in the living standard of the population and the attainment of a high and sustained rate of economic growth appear to be the major objectives of development planning. Some of the less developed countries have achieved at least partial success in this regard through the rapid exploitation and export of locally available raw materials such as forestry products, one of the few resources with the important characteristic of being renewable. In the foreseeable future, it appears that forests may be able to make significant contributions to economic development in these countries especially in view of the predicted worldwide increase in demand for forest products.

A number of important contributions to economic development have been identified, but an economic evaluation of forestry development projects may be of prime importance, if the maximum advantage is to be obtained from the role of forestry.

An important conclusion arrived at as a result of this study was that forestry development projects should be adequately evaluated before any decision is made as to whether or not they should be undertaken. Cost- benefit analysis was used in this study to derive the economic profitability of the forestry plantation development programme at Byfield in central Queensland. This method of analysis was adopted in preference to Faustmann's formula

which has been traditionally used to calculate the economic value of land for commercial purposes because of the greater relevance of cost-benefit analysis to the problems of project selection in the less-developed countries. The evaluation was undertaken from both the viewpoint of Queensland Department of Forestry and the nation as a whole but the scope of the study was restricted to the production of sawlogs valued at the stump.

The analysis carried out from the viewpoint of the project's initiators,the Queensland Department of Forestry indicated that the investment gave a reasonable return on capital under present management practices. However, through the mechanisation of the establishment and silvicultural operations and a real increase in stumpage prices over time a rate of return of between 7 and 8 per cent was achieved.

The social cost-benefit analysis undertaken from the nation's viewpoint indicated that the development of the Bowenia plantation contributed a positve discount net social benefit if developed and managed as a sustained yield forest provided it is able to substitute satisfactorily for the softwood sawntimber which is likely to be imported into the region in the future. Under the present rate of development, the nation not only gains overseas exchange through import replacement of sawntimber in the Rockhampton region but also gains an increase in the level of economic activity in the rural area where the plantation is located. In view of the limitations of the analysis and the likely changes in future real market prices of imported sawntimber and development costs, the results obtained from the Bowenia plantation programme at Byfield indicated that it will be a satisfactory social investment.

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CHAPTER I

INTRODUCTION

1.1 General

World demand for wood has steadily increased for many years and this trend appears likely to continue in the foreseeable future (FAO,1967). In 1976, world production of industrial wood and fuelwood reached 1.4 billion cubic metres roundwood(r) and 1.2 billion cubic metres roundwood (r) respectively (FAO,1976a). World requirements of industrial wood for the year 1985 were forecast to rise to approximately 2 billions cubic metres (r) (IBRD,1973) while world fuelwood requirements for 1985 were expected to remain much the same as they were in 1973 (IBRD,1973), due to the substitution of other products, as source of energy, in place of fuelwood. However, the rapid increases in energy costs, the reduction in world economic activity and the difficulties of reducing the high level of inflation and unemployment has cast considerable doubt on the validity of these forecasts particularly the fuelwood forecast made by the IBRD in 1973. While wood is important as a domestic and industrial fuel in the developing countries, up till 1973 per capita fuelwood consumption was declining . However, a similar decline in fuelwood consumption is now for less likely to occur especially in view of the recent difficulties experimented by the developing countries in obtaining alternative fuels. The recent increases in fuel prices, have led the developing countries to show increased interest in using more wood as fuel . Consequently forestry is likely to play an important role in the economies of these countries, particularly in the South East Asian region.

1.2 Importance of forest products in the economies of the less developed countries. (LDC)

Forest products in the South East Asian region consist mainly of tropical hardwood and represent an important source of export income. In 1976, in the South East Asian region, wood production was estimated to be 73 millions cubic metres (r) of industrial wood and 210 millions cubic metres (r) of fuelwood (FAO,1976a). In the same year, exports of tropical hardwood from this region totalled 38 millions cubic metres(r) and were valued at about $US 1.5 billion (FAO,1976a). The 1972 level of exports of sawlogs of these species is expected to double over the next ten years, in response to a rapidly increasing demand (IBRD,1973). At the same time increases in living standards are expected to cause a significant rise in the domestic requirements of wood, both per capita and total. In 1976, in the South East Asian region, the total consumption of sawlogs and veneer logs was estimated to be 35.5 millions cubic metres(r).

By the year 2000, the total consumption of sawlogs has been forecast to rise to one billion cubic metres (r), an annual average increase of 3 per cent per annum (FAO,1973). The expected corresponding growth rates for paper and paper products and wood-based panel products are such that total consumption will be five times the 1975 figure. The actual and forecasted total consumption of forest products in the region are shown in Table 1.1.

Both the domestic demand for sawnwood in the South East Asian countries and the world demand for tropical hardwood are expected to grow at least until the turn of the century, (Takenji Kenji,1974),(Zivnuska,1970) and (USDA,1973). However recent world economic developments may have made these forecasts optimistic. In the less developed countries export earnings have largely been dependent on the exports of agricultural and forest products. Given this situation and the substantial tropical hardwood resources of these countries, particularly tropical hardwood resources still available within the South East Asian region, appear to offer an excellent foundation on which to base economic development.

The potential of forests, a renewable natural resource, to play an important role in the economic development of many countries occasionally seems to pass unnoticed. Existing forestry resources can be readily exploited to assist a country's economic development through the demand for skill labour, infrastructure and its imports on foreign exchange earnings. However exploitation per se does not necessarily mean that sufficient attention is given to the long run management and replacement of these resources. This may be because of the long term nature of forestry plantations whose benefits are not normally generated until many years after the initial investment.

TABLE 1.1

ACTUAL AND FORECAST TOTAL CONSUMPTION OF FOREST PRODUCTS, 1960-2000, IN INSULAR SOUTH EAST ASEA AND CONTINENTAL ASIA

END PRODUCTS	-	1960+	1965+	1970+	1976+	1980	1985	1990	2000
Sawnwood	-	6200	7850	9050	13165	14600	20100	29000	60000
Plywood & veneers	1000m3	190	280	410	802	700	990	1450	3240
Particle board	-	18	51	55	90	130	210	350	990
Fibreboard	-	70	145	130	150	210	300	425	900
Newsprint	-	180	240	380	550	780	1100	1530	2900
Printing & writing paper	1000m.t	150	280	400	700	1110	1810	2040	5500
Other paper	-	390	520	1080	1460	1860	2450	3080	4950
Roundwood equivalent									
Sawlog &veneer	1000m3	10200	14900	17400	35700	28000	39000	56000	117000
Pulpwood	-	2950	4000	6200	8000	11200	16000	22200	41900

Source: FAO,1973 and 1976

+Actual consumption

1.3 The role of forestry in the economy

The depletion of natural forests by shifting cultivation, the pressure for land to be used for agriculture, the low increment of natural forests and the difficulties faced in the natural regeneration of hardwood forests, are factors which have combined to reduce the supply of forest products from the South East Asian region in recent years (FAO,1976b). This trend is unlikely to change in the near future (FAO,1976b). Conversely, the recent substantial increases in the demand for industrial wood, as well as for other forest products over the last decade has highlighted the need for better management of the existing forests, as well as for a greater investment in silvicultural improvements and forest development. Increased domestic production has the potential not only to meet increasing domestic requirements but also to maintain or generate an increase in export earning from logs or processed wood products. The economic benefits received from exports will be related to the level of internal processing and the industrial efficiencies achieved.

1.4 Forestry in regional development

There are important and fairly substantial secondary benefits to be gained from increasing the output of forest products in the region. Foreign exchange earnings and import replacement capacity are obvious benefits which could combine to make significant contributions to a LDC country's economic development (Gamble,1968),(Greig,1971) and (Westoby,1962). Westoby(op.cit) demonstrated that forest industries have well developed multiplier effects and external economies. Westoby's findings are borne out by Bednall (1966) who claimed the afforestation programme in South Eastern Australia made a significant contribution to development in terms of both population growth and employment opportunities. He concluded that the growth of population and the degree of urbanisation of the Mount Gambier region has shown a greater rate of development with large scale afforestation and a forest based industrial structure than the region would have experienced without such industries. He did not ,however, measure the economic efficiency of such development.

Apart from these effects, forestry can play an important role in the economy through its contributions to recreation, water catchment, erosion control, fauna and flora conservation and so on (Bacon, 1970). These benefits are not easily measured in monetary terms but are generally regarded as relatively significant to the economy (Ferguson et al.,1973);(Grayson,1972).

1.5 Plantation forestry

Most of the less developed countries (LDC's) undertake forestry programmes aimed at increasing the productivity of their forest resources through the establishment of plantations, or through appropriate silvicultural programmes, for the reasons described in the previous paragraph.

It is doubtful whether major increases in productivity can be gained from the intensive management and natural regeneration of tropical harwood forests. In many countries large areas of natural forests are already heavily committed to supply logs for either local industry or exports. The principal limitations to increasing supplies from currently utilised forests is the problem of location and the complexity of the species they contain. The most important factors inhibiting the large scale commercial exploitation of tropical forests were set out in Unasylva (1965) and has been summarised as follows :-

1. The composition of many different species creates problems in processing for industrial purposes and in harvesting. Furthermore, the natural regeneration of hardwood species is very slow and uncertain because of this characteristic.

2. Few of the natural species are normally suitable for industrial purposes.

3. Most of the major areas of productive tropical forests are relatively inaccessible.

4. Tropical forests are characterised by a low rate of volume increment (usually less than 1 to 2 cubic metres per hectare) compared to those of most softwood species.

In most countries, in an attempt to overcome these problems, emphasis is given to either indigenous or exotic plantations of fast growing species. In the production of industrial wood, these species offer the following important advantages :-

1. An appropriate choice of species enables an homogenous crop of wood raw material to be produced.

2. The mean annual increment of fast growing species varies from 15-20 cubic metres per hectare, per annum. At this rate of growth plantations of fast growing species can produce sawlogs of acceptable size, in 20 years or more, while pulpwood can be produced in 10 to 12 years. By comparison, the corresponding figures for hardwood species vary from 60 to 80 years.

In view of these aspects many South East Asian countries have commenced plantation programmes. In 1970, the total area of plantation within the South East Asian region was 223,000 hectares of coniferous species and 795,000 hectares of non-coniferous species. By 1990, coniferous plantations are expected to increase to 405,000 hectares of coniferous species while plantations of non-coniferous species are expected to increase to 1,225,000 hectares (FAO,1976b).

1.6 Background to the study

It is most unlikely that the natural forests, currently one of the major sources of supply of forest products in South East Asia, will be able to meet the increased demand for forest products anticipated in the future (FAO,1976b). Consequently an increased investment in forestry plantations is of considerable importance for the sustained future development of the economies of most countries in the South

East Asian region which are heavily dependent on forestry exports. This is especially important where these countries have a forecast deficit between the demand and supply of forest products from indigenous forests.

Capital is relatively scarce in most of these countries and as plantation forestry is both capital intensive and generally a long term investment, priority is usually given to short-term projects which give high returns on capital. Therefore, the allocation of capital, land and labour to plantation forestry is limited by market forces and in a number of cases by the short-term outlook of the decision makers. Consequently, in most of the less developed countries, plantation programmes are still in the developmental stage and full-scale operations on most plantations will not be achieved for a considerable time. However , the introduction of exotic pine in the forestry development programmes of South East Asian countries has generally been given high priority because softwood species have a number of highly desirable advantages in some end uses over indigenous hardwood.

These forestry programmes have increased the competition for land which is becoming a major problem in some countries. Traditionally, agriculture has received the highest priority and usually occupies most of the fertile soils while plantation forestry is generally restricted to areas considered less desirable for agriculture. These areas are usually located on infertile soils no longer suitable for shifting cultivation, or in forest areas not commercially exploitable for other forest or agricultural production.

Cost-benefit analysis can be used to indicate the relative social worth of competing land uses and has been used extensively in government resource allocation. However, accuracy of the results is heavily dependent on the accuracy of the data and the assumptions used in the analysis. Data deficiencies, both physical and financial, are however common in most of the less developed countries. Advice received from staff of the Department of Forestry, the Australian National University, together with recommendations made by the Queensland Department of Forestry, indicated that it was preferable to undertake this type of study in a developed country where reasonably data was available in sufficient detail. As a result, the Bowenia plantation at Byfield, in the Rockhampton region of Central Queensland, was selected for the study. Being situated within the tropics it was considered to have similar climatic and other characteristics to those of many of the areas being developed for plantations in the less developed countries of South East Asia.

This study outlines the use of Cost-benefit analysis on this particular forestry plantation project. The technique of Cost-benefit analysis is described and is then used to examine the efficiency of allocating scarce resources in the plantation project. The project is analysed from two points of view :-

1. From the Forestry Department viewpoint, the profitability of the plantation must satisfy a specified departemental management objective.

2. From the national viewpoint, this requires the project's social profitability to be investigated.

In Chapter 2, the importance of the various forest industries and non forest industries in the Rochampton region is outlined. The existing demand and supply of forest products in the region , and of forecasts of these variables, are discussed to show the important role of forestry particularly that of the forestry plantation development programme within the region.

The description of the plantation project, its geographical background, the techniques of establishment, and the management practices used, are outlined in Chapter 3.

A review of the literature covering the techniques of project evaluation and Cost-benefit analysis relevant to forestry is presented in Chapter 4. The methodology and the assumptions underlying the use and derivation of the Net discount revenue of the project are examined. The method of measuring the costs and the benefits of the project are outlined and the selection of the discount rate is discussed.

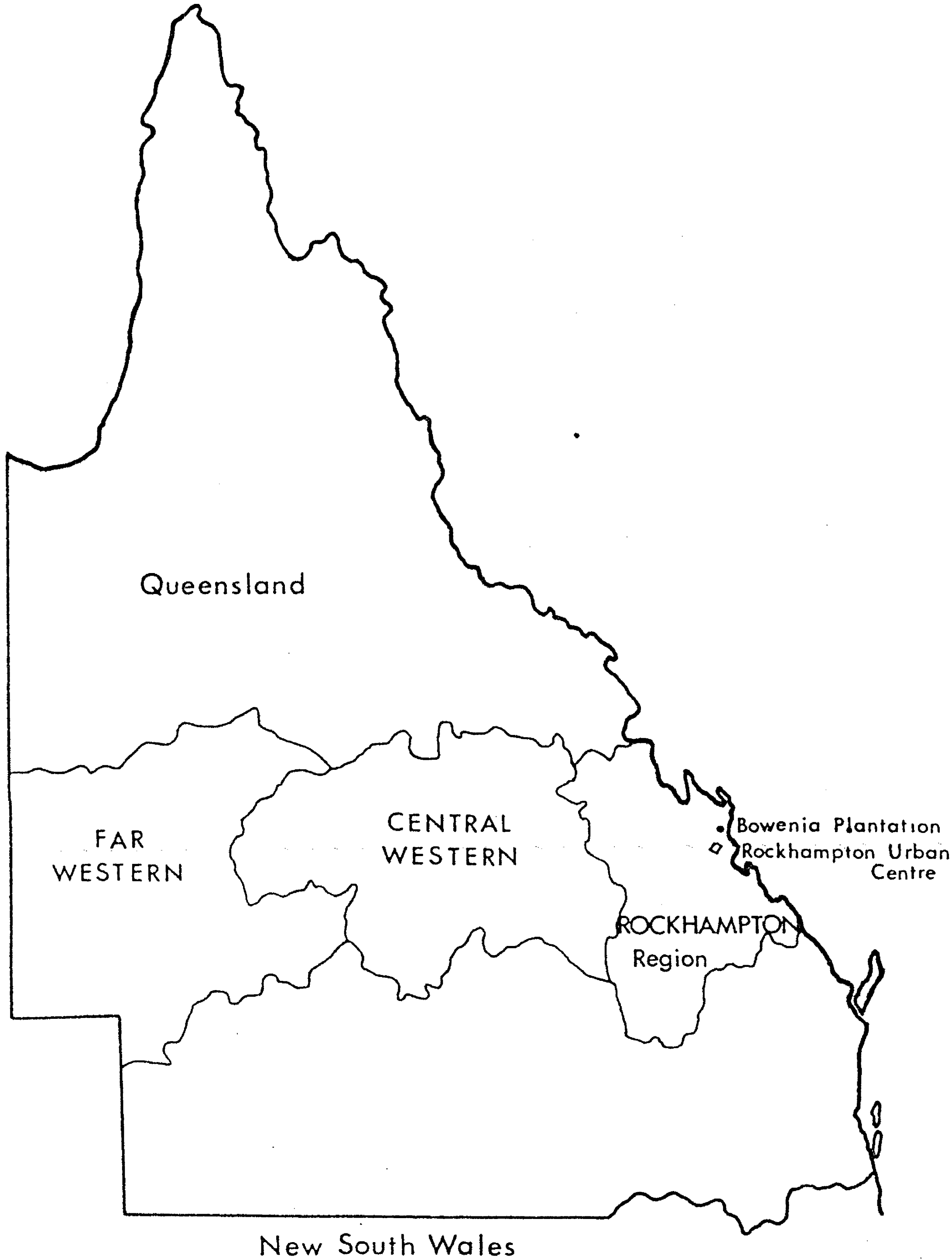
Chapter 5 outlined the market situation of sawntimber in the Rockhampton region. Relevant stumpage shadow prices based on the import replacement of sawn Douglas fir from the United States and sawn Pinus radiata from New Zealand are derived on the assumption that these prices are a better indication of the true social values for social cost-benefit analysis than market prices are. The specific revenues, costs, and cash flow of the project are derived in Chapter 6.

In Chapter 7, the result of the analysis, from the Department of Forestry's viewpoint, are presented and discussed.

The revenues and costs used to derive Net Social Benefit are given in Chapter 8 and the results of the social cost-benefit analysis are presented and discussed in Chapter 9.

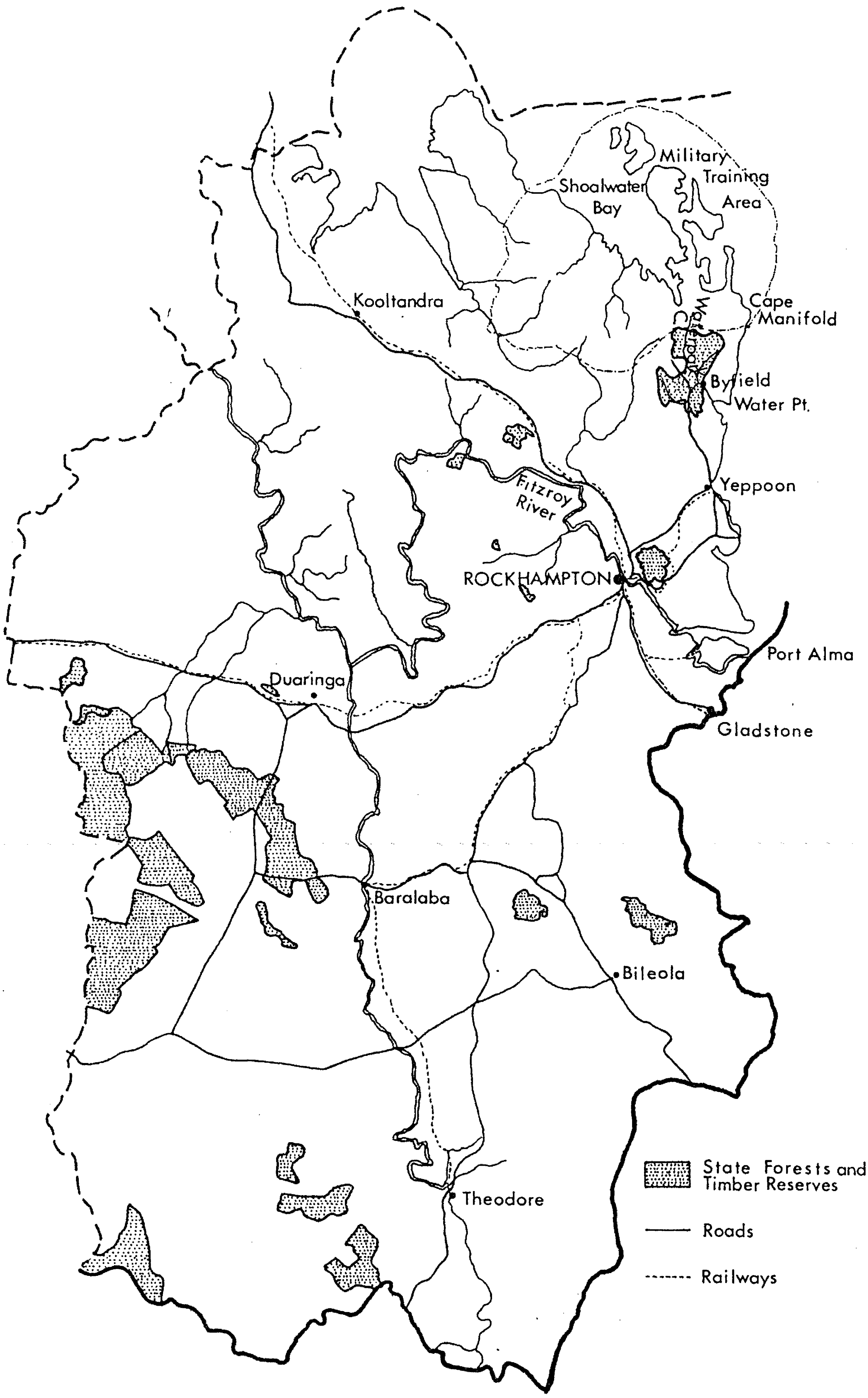
MAP 1

Map of Queensland showing the location of Rockhampton region and the Bowenia plantation at Byfield.



MAP 2

The study area : Rockhampton region



CHAPTER 2

THE IMPORTANCE OF FORESTRY IN THE ROCKHAMPTON REGION

2.1 General

The area and bounderies of the Rockhampton region in this study coincide with the Rockhampton Local Authority areas of the statistical division of Queensland and covers an area of 102,575 square kilometres. The region produces a wide variety of crops and has the highest density of beef cattle in Queensland as well as containing substantial mineral deposits of coal, copper and gold and a large area of indigenous forests along the moister coastal ranges. These indigenous timber resources represent the main source of supply for forest products required by the local markets.

Dry sclerophyll eucalypt forests constitute the main forest resource of the sub-district and some 407,488 hectares of the more productive of these forests have been permanently reserved as state forests. An additional area of 39,934 hectares has been set aside for wood production as timber reserves under less secure tenure (Queensland Department of Forestry, Annual report, 1975).

The supply of timber from natural forests in the sub-district makes a major contribution to the local sawmilling and building industries. Some 90 per cent of the total annual sawnwood production was produced from native hardwood while native softwood(Cypress pine, Hoop pine, Kauri and Bunya pine) are responsible for the balance (Queensland Department of Forestry, 1974. pers. comm.)

2.2 Timber industries in the region.

The number of sawmills operating in the Rockhampton region declined from 43 in the September quarter of 1970 to 31 in the september quarter of 1977. The number of sawmills according to quarterly licenced capacity restriction on the intake of sawlogs per quarter is summarized in Table 2.1. Only two sawmills, one located at Rockhampton and the other at Dingo, have a total annual intake of sawlogs of 8000 m3 or over. The sawmills at Yeppoon and Byfield are much smaller.

TABLE 2.1

NUMBER OF MILLS OPERATING: TYPE OF MILL

SEPTEMBER QUARTER 1970/1977

(Sawmills with Quarterly Capacity)

(m3 of Sawlogs)

Period (Quarter)	Under 700m3	700m3 and under 2000m3	2000m3 and over	Total -
Sept. 1970	29	12	2	43
" 1971	30	15	2	47
" 1972	31	13	2	46
" 1973	27	12	2	41
" 1974	17	6	3	25
" 1975	18	7	4	29
" 1976	18	7	5	30
" 1977	18	8	5	31

Source : ABS, Queensland office

In 1977, the area's total sawnwood production was 71675 m3, consisting of 59,116 m3 of native hardwood , 3412 m3 of native softwood and 9152m3 of plantation softwood (Queensland Forestry Department ,1974. pers. comm.) and ABS(various). This represents close to 12 per cent of the total sawnwood production of Queensland.

Sawnwood production from native timber reserves has declined from 66,353 m3 in 1964 to 59,116 m3 in 1977. Over the same period, the quantity of softwood production from plantations has continued to increase from 1611 m3 in 1969 to 9152m3 in 1977. The types and proportions of tree species milled in the Rockhampton region from 1964 to 1977 are shown in Table 2.2.

2.3 Other wood-using industries

Rockhampton has four joinery firms and one furniture manufacturer which utilise locally milled hardwood, some softwood mainly imported from South Queensland and an appreciable quantity of cabinet woods brought by rail from the Cairns district (Department of Northern Development, 1969).

Joinery, cabinet making, and sawmilling were the only wood-using industries in the Rockhampton region when this study was undertaken . The possibility of establishing a paper and pulp industry using bagasse- the crushed fibre residue of sugar cane - within the Bowen region was however under investigation by the Department of Northern Development. The development of such an industry is

TABLE 2.2

SAWNWOOD PRODUCTION OF HARDWOOD AND SOFTWOOD
IN CENTRAL QUEENSLAND, 1964/1977
(cubic metres)

	NATIVE FORESTS					PLANTATIONS		
Year -	Hoop pine Bunya,Kauri	Cypress pine	Hardwood -	Cabinet Woods	Misc. -	Hoop pine Bunya,Kauri	Others -	Total
1964	1406	3837	66353	-	14	216	-	71726
1965	1710	4814	61426	7	94	2	123	68176
1966	1375	4108	61131	5	57	-	50	66726
1967	1017	3629	59836	-	5	-	87	64574
1968	429	3731	56183	-	14	-	59	60416
1969	354	4224	59753	19	5	1543	68	65966
1970	479	4840	58120	-	-	1635	17	65074
1971	210	4309	60664	-	19	831	50	66083
1972	866	5118	63111	-	26	1159	68	70348
1973	359	5260	57795	-	-	1760	-	65174
1974	526	4068	51591	-	-	1928	-	58113
1975	272	2959	49787	-	36	3199	19	56278
1976	555	3198	63938	-	-	5337	929	73765
1977	681	2731	59116	-	-	5819	3333	71675

Source: ABS,Queensland office, 1964+

unlikely in the Rockhampton region because most of the raw material is produced in the Bowen area although some coniferous rounwood would be available from the plantation at Byfield to complement the supply of bagasse.

2.4 Other industries

The Rockhampton region produces a large range of crops and is the major beef producing area in Queensland (Department of Northern Development ,1969). In 1973/74 the area produced 18 per cent of Queensland's total gross value of livestock production and had 1,658,ØØØ or over 35 per cent of the Queensland total beef cattle and a little over 3 per cent of the Queensland's total sheep population (ABS,1974a).

Mining industries are also very important as a result of the extensive mineral resources of coal, copper, bauxite,etc. found in Central Queensland with the known resources of coal being largely confined to the Rockhampton region. Production of coal has expanded rapidly in recent years, increasing from 56,2Ø8 tonnes in 1966 to 7.5 millions tonnes in 1975 (Queensland coal Board ,1975). Exports of coal were estimated to be 7 millions tonnes in 1975, about 93 per cent of the total production being export to Japan. The value of coal production has increased from $35 millions in 1968 to $1Ø7 millions in 1973 .

2.5 The region's demand for timber

The Rockhampton and Gladstone urban centres are the major growth centres of the region. A major feasibility study into the establishment of future major industries including an iron and steel industry, an aluminium industry, a nickel industry, and a metallurgical coke and caustic/soda-chlorine industry has already been undertaken (Department of Northern Development , 1974) The region's population over the next 25 years was estimated to increase by over 50,000 as a result of the expected industrial growth (Department of Northern Development,1974). Consequently, the future demand for timber within the region is expected to rise significantly. Predictions of the region's demand for timber were made based on firstly the forecast per capita consumption for Australia given by the FORWOOD conference and secondly using the Queensland Department of Forestry estimates which cover the period 1971 to the year 2000 .

The FORWOOD(1975) forecast of timber consumption per capita for Australia from 1971 to the year 2000 is given in Table 2.3. Preliminary population forecasts were made by the Co-ordinator General's Department in 1973 (pers.comm.) and are presented in Appendix 2.1 (1). Population forecasts were used in conjunction with the FORWOOD estimates of per capita consumption of timber to obtain regional forecasts of the total consumption of sawnwood and other wood products to the year 2000. On this basis, by the year 2000 the total consumption of wood products in Gross Round Wood Equivalent (GRWE) was estimated to be

TABLE 2.3

FORECAST PER CAPITA CONSUMPTION OF SAWLOG ,
PULP AND PAPER PRODUCTS AND PANEL PRODUCTS IN THE
ROCKHAMPTON REGION, 1971-2000 .

Year	Sawlog (m3 p.a.)	Pulp & paper (tonnes p.a.)	Panel products (m3 p.a.)
1971	0.3585	0.1208	0.0453
1980	0.3347	0.1516	0.0736
1990	0.3089	0.1817	0.0918
2000	0.3068	0.2115	0.1058

Source : FORWOOD 1975

319,795 m3. This comprises 140,285 m3 of sawntimber, 145,840 m3 of pulp & paper products and 33,670 m3 of panel products . Details are presented in Table 2.4.

The Queensland Department of Forestry estimates of per capita consumption of forest products for the state were given in Appendix 2.2. For the financial year 1971/72 the per capita consumption of sawntimber was 0.143 m3 (GRWE) higher than the national average level of consumption while the per capita consumption of pulp & paper products and panel products was 0.05 m3 (GRWE) lower than the national average level .

The per capita consumption figures and the Coordinator General's Department population forecasts were used to derive alternative estimates of future total wood product consumption. The year 2000 estimates of consumption were 151,000 m3 (GRWE) for sawntimber and 155,000m3 (GRWE) for pulp& paper products and panel products giving an overall total of 306,000 m3 (GRWE) .

Although regional anomalies could cause the per capita consumption figures to diverge from the national average for sawntimber and other products, the total consumption estimates for forest products in the Rockhampton region from those two sources are a reasonable indication of likely future developments.

1) these projections appear optimistic in view of a more recent work by Borrie.

TABLE 2.4

FORECAST TOTAL CONSUMPTION OF SAWNTIMBER, PULP AND PAPER AND PANEL PRODUCTS AND THEIR FORECAST TOTAL CONSUPTION IN ROUNDWOOD EQUIVALENT IN THE ROCKHAMPTON REGION ,1971-2000

	TOTAL CONSUMPTION			
	Sawntimber	Paper	Panel	Total
	-	products	products	
Year	(000m3)p.a.)	(000t.p.a.)	(000m3)p.a.)	(000m3)RWE
1971	41.048	13.832	5.187	163.785
1980	46.691	21.148	10.267	214.318
1990	48.652	28.672	14.486	254.783
2000	56.114	38.683	19.351	319.795

Footnotes :

1m3 of sawntimber = 2.5 m3 log equivalent

1m3 of panel products= 1.74m3 log equivalent

1 tonne of papers products = 3.77m3 log equivalent

Source : FORWOOD 1974

2.6 The region's supply of timber

Indigenous reserves in the Rockhampton region area outlined in section 2.1 , are typically low grade eucalyptus forest FORWOOD(1974). Although these reserves currently contribute about 90 per cent of the total sawlog supply, present removals are above the maximum sustained yields. This problem will be aggravated in the future as some forests areas will be transfered either to national parks or for purposes other than being used as a source of timber (FORWOOD,1974). Consequently, the estimated future increases in demand for wood and wood products are unlikely to be met from the existing indigenous forest resources of the region.

Estimates of the future availability of forest products from the Rockhampton region were presented in FORWOOD (1974) and are given here in Table 2.5 . This table shows that sawlog production from indigenous forests (Broadleaved and coniferous) within the region is expected to decrease steadily from 74,100 m3 (GRWE) in 1975 to 60,700m3 in the year 2000 . Sawlog production from the region softwood plantations is expected to increase from 7800 m3 (GRWE) to 96000m3 (GRWE) over the same period.

The future supply of piles & poles and mining timber produced within the region is expected to remain constant at about 36000 m3 (GRWE) , while the production of pulwood products from the coniferous plantation is expected to rise from 12900m3 to 19200m3 (GRWE) over the same period (FORWOOD,1974).

TABLE 2.5

FUTURE AVAILABILITY OF FOREST PRUDUCES IN THE

ROCKHAMPTON REGION , 1975-2000

(m3)

-	-	1975	1980	1990	2000
Native Broadleaved	Sawlogs	61600	61600	58200	48900
-	Others	36000	36000	36000	36000
Native coniferous	Sawlogs	12500	12500	11800	11800
Plantation	Sawlogs	7800	20400	47700	96000
coneferous	Pulpwood	12900	17100	17100	19200

Source : FORWOOD 1974

a) Sawlogs include railway sleepers

b) Poles,piles and mining timber

2.7 Supply/Demand balance of Forest products in the Rockhampton region.

Turnbull(1959) and Hanson(1959) forecast that the future Australian forest products requirements would exeed the available supply from native forests and both authors proposed that a softwood plantation programme must be implemented . The prospective future shortage of forest products in the Rockhampton region based on the more recent FORWOOD estimates would tend to support their views.

The Australian Softwoods Forestry Agreement Act of 1972 estimated that some 1.2 millions hectares of Softwood plantation, planted at an annual rate of 30,000 hectares, would be required by the year 2000 to meet the forecast Australian demand for wood products. In Queensland, the Department of Forestry has proposed that an area of 162,000 hectares of effective Softwood plantation is needed if the state is to achieve self- sufficiency in forest products by the year 2000 (AUSTRALIA,1975). Of the total area some 60,000 hectares was to be native conifer plantation (mainly Hoop pine). The balance was to be made up of fast growing exotic coniferous species.

However, the forecast of demand and supply for forest products from native forests in the Rockhampton region presented in Table 2.4 and Table 2.5 indicated a deficit of some 223,090 m3 (GRWE) of sawlogs, pulp & paper products and panel products by the year 2000 .

TABLE 2.6

DEMAND/SUPPLY OF SAWLOG IN THE ROCKHAMPTON REGION TO THE YEAR 2000

in cubic metres RWE

Year/Items	1975	1980	1990	2000
1-NATIVE FORESTS				
Broadleaved	61600	61600	58200	48900
Conifers	12500	12500	11800	11800
2-PLANTATION				
Conifers	7800	20400	47700	96000
Total supply	81900	94500	117700	156700
Total Demand	102620	116730	121630	140290
Demand - Supply	-20720	-22230	-3930	16410

This total deficit was based on a sawlog deficit of 79,590 m3 (GRWE) with the remainder made up by pulp & paper products and panel products . As it would be uneconomic to develop a local pulp & paper industry just to meet the regional deficit it was assumed that the supply of pulp & paper products and panel products to the Rockhampton region would be imported. The forecast supply of pulpwood product to the year 2000 represent only 11 per cent of the total demand in GRWE. On the other hand, the sawlog supply forecast from the plantation is expected to meet the requirement within the Rockhampton region and presented in Table 2.6.

Logs and most types of sawntimber are heavy and bulky and therefore there are fairly definite limitations to the distance to which they can be economically transported. One objective of the Forestry Department is to increase local timber production from suitable forest areas as close as to the centre of consumption, as possible. Economic factors, particularly the excessive transport costs would make this a justifiable objective for the Rockhampton region which is geographically isolated and which would make the transportation costs of importing sawntimber from other parts of Queensland prohibitive.

Softwood plantations have advantages over hardwood plantations because the softwood timber is able to meet a wider range of end-uses than hardwood timber. Consequently, softwood timber is less vulnerable to uncertain market conditions than hardwood. Furthermore, the characteristics of softwood give them an advantage over hardwood, as mentioned in section 1.5 . The Queensland Forestry Department's main softwood plantation in the region is state forest R20 located at Byfield about 100 kilometres from Rockhampton the major market in the region. This plantation was developed to meet local timber requirements within the region rather than rely on imports of timber from Southern Queensland or from Overseas.

The plantation at Byfield normally provides seasonal employment for some 30 to 40 people from the surrounding areas annually and is now becoming the main source of local softwood sawlogs. In 1974 , the allowable annual cut was estimated at 11,250 m3. This was expected to rise substantially to 24,000 m3 per annum by 1884 (Queensland Forestry Department, 1974.pers.comm.) .

With a planting rate of 200 hectares per annum, sawlog production will rise to 120,000 m3 per annum when the plantation reaches the sustained yield stage by the year 2014 .

CHAPTER 3

DESCRIPTION OF THE PLANTATION PROJECT

3.1 Geographical background

The Bowenia plantation at Byfield comprises the state forest reserves R20, in the Parish of Maryvale, and R28, in the Parish of Coolingbah, and forms an important part of the activities of the Rockhampton forestry sub-district. The plantation is situated at latitude 22°50' south and in 1974 covered an area of 13,760 hectares of state reserve R20 and 13,260 hectares of state reserve R28. The plantation project was bounded on the North and West by the Schoalwater Army Training Centre which would prevent any large scale expansion of state forest reservation in that direction. The Pacific Ocean forms the eastern boundery, while the southern boundery adjoins the pasture land. The plantation is situated about 34 kilometres North of the Yeppoon urban centre. Yeppoon is basically a tourist resort with a population in 1971 of 4,400 (ABS,1974a).

The climate varies from humid subtropical to semi-arid. Rainfall being a very important factor in determining the type of rural development in the region . Approximately 70 to 75 per cent of the total annual rainfall occurs in the warmer months from October to March, with January or February usually being the wettest. Total annual rainfall ranges from 760mm to 1270mm, but areas receiving over 1270mm occur just North of Yeppoon. The mean maxima summer temperature varies from 26°5'C to 43°C with January being the hottest month. July is the coldest month with mean minima temperatures ranging between 11°5' to 14°C .

The soils of the plantation which have developed on the flat to gently undulating costal plains consist mainly of shallow bleached sand underlay by mooled yellow grey clay subsoils. The main soil types and their contents are shown in Table 3.1.

3.2 Vegetation

Vegetation studies of the central Queensland region were carried out by the Department of Northern Development (1965), Forestry and Timber Bureau (1957,1970) and Forwood (1974).

The dominant forest type in the region are low grade dry schlerophyll eucalypt forests classified as Eucalypt productivity class III (FORWOOD,1974). The dominant species being *Eucalyptus paniculata* (grey ironbark),*E. melliodora*(yellow box),*E.propinqua* (grey gum),*E.microcarpa* (grey box), and *E.crebra* (narrow leaved ironbark), while species of lesser importance are *E.fibrosa* (broad-leaved red ironbark),*E.acmenioides* (white stringybark) and *E.phaeotricha* (Queensland white stringybark). The understory consists mainly of annual species and wattles *Acacia spp*. While the types vary widely differenciation into major and minor tree species was not made. The minor species include *Syncarpia glomulifera* (Turpentine),*E.moluccana* (grey box) and *E.crebra* (Narrow-leaved red ironbark). Forest trees in the area have no commercial value.

TABLE 3.1

CLASSIFICATION OF SOILS IN THE STATE FOREST R20

Categories	Contents soil types	Area (Ha)	Percentage
Good soils	1.Black loamy sands	-	-
Slope 5-10%	2.Dark brown loams	-	-
	3.Dark grey loams	299	2.7%
	4.Black alluvium	-	-
Fair soils	1. Grey brown alluvium	-	-
Slope 1.5-5%	2. Brown clay loam	6943	63.5%
	3. Black clay loam	-	-
	4. Dark brown sand	-	-
	1. Grey sands	-	-
Poor soils	2. Grey&grey brown clay	-	-
	3. Grey brown sands		
Waste	1. Waterlogged clays	-	-
-	2. Waterlogged sands	1473	13.5%
Total		10929	-
Creeks&Gully		2831	-

Source :- Bowenia Forestry Station, 1974.

3.3 The Bowenia plantation

3.3.1 History of the plantation.

Species trial plots were commenced at Byfield in 1929/30 on an area of approximately 2 hectares. The species used in the trial were *Araucaria Cunninghamii* (Hoop pine),*Pinus teada*,*Pinus Kesiya*,*Pinus elliottii*(slash pine) and some Eucalypt species. The trials continued with minor expansion until 1949 when a small scale planting programme using slash pine was started, and some trial plots of *Pinus caribaea var.Hondurensis* were established. Plantings of slash pine gradually increased from 26.9 hectares per annum in 1949 to 111 hectares per annum in 1959, while the *Pinus caribaea* planting increased from 0.8 hectares in 1949 to 200 hectares in 1961. The results obtained from the Bowenia species trial plots together with other studies of the growth of *Pinus caribaea* in the tropical and sub-tropical region of Queensland showed that *Pinus caribaea* had a faster growth rate than either slash pine or any of the other native softwood (Slee, *et al.* 1967) and (Nikles, 1973) . Consequently,after 1961,*Pinus caribaea* was the only species planted and by 1973/74 some 2907 hectares had been established.

3.3.2 Site Index

Site index is measured from the predominant height achieved or anticipated at age 25.5 years. Predominant height is the average height in metres of the tallest tree taken every 0.02 hectares. At Bowenia, a 15 per cent sample was taken to determine the site index. This was achieved by dividing the particular project into a grid system. A plot 50 metres long was selected every 3 rows to give a plot area of 0.247 hectares for a spacing of (2.7x2.4) metres and one plot every four hectares was chosen from each compartment.

Site indices for both Pinus elliottii and Pinus caribaea were calculated. The site indices for Pinus elliottii was found to very from less than 15 to 27. Out of the 965 hectares of P.elliottii planted, some 35 per cent had a site index less than 18, 40 per cent had a site index 18, and only 25 per cent had a site index greater than 18. The total area of site index for Pinus elliottii by planting years is given in Appendix 3.1 .

The site index of Pinus caribaea varied from less than 21 to 39 . Of the total area of 1253 hectares planted, 29 per cent had a site index less than 27, 42 per cent had a site index of 29, and 30 per cent had a site index greater than 29 . Appendix 3.2 gives the Pinus caribaea areas of site index by planting years.

A higher site index, varying between 24 and 30, was found on the moist sites where the depth of soil was greater than 76cm, and was characterised by deep sand loams. For deep but poor drained loam soil of less than 60cm the site index expected was approximately 21 .

Most of the areas of site index 24 closely follows the path of creeks and gullies and are located in shallow depressions (Bowenia office,1974 pers. comm.) .

Improvement of establishment techniques, application of fertilizers on poor sites and the construction of an open drainage system on swampy areas are being carried out to improve any area estimated to have site index less than 29. The local forestry officials considered that all areas should have site index between 29 and 31 if they were to be economical.

3.3.3 Selection of species

Earlier studies of exotic species at Bowenia plantation at Byfield (Queensland Forestry Department,annual report,various) also indicated the superiosity in growth and vigour of Pinus caribaea over slash pine and the more recent site index studies (section 3.3.2) have confirmed the Department's view that Pinus caribaea was the most suitable species for timber production in the sub-tropical and tropical regions of Queensland. The criteria used in the recent studies were growth rate in the sub-tropical region(Nikles et al.,1968), (Gardner ,1971) ; the ability to produce sawlogs (Hawkins et al. 1972), and the wood properties and pulwood quality (Smith,1973) . Pinus caribaea is superior in all the areas to Pinus elliottii and other species tested. Since 1962, the Bowenia plantation at Byfield has been planted only with Pinus caribaea.

3.3.4 Establishment methods

Site clearing was usually carried out between August and November, some six months before the area was to be planted. The vegetation was felled and heaped by crawler tractors and was burnt when dry. The cleared area was then ploughed with a second ploughing occasionally being necessary to avoid regrowth of vegetation. Ploughing was done to an average depth of about 25cm with a minimum of 20cm. The department used Shearer Majestic ploughs, which were stump jump type having eight 81cm diameter discs. The ploughs were usually pulled by County 4 tractors. Open drains are essential in swampy areas to remove any excess water before planting. If the excess water could not be adequately controlled by the open drains then mounding was also used. These techniques were applied as a result of previous experimentation with mounding on swampy sites used for timber production in the " Wallum " country of South Eastern Queensland. Mounding was carried out by a mounted plough pulled by a county four wheeled tractor and the mounds were approximately 60cm wide and 30cm high. As a rule, open drains were approximately 60cm wide and averaged 50m in length for every hectares planted. The average cost in 1974/75 of the drainage systems was estimated to be $5 per hectare, whereas ploughing, mounding and ripping were respectively $30, $20 and $27 per hectare.

The debris was either windrowed or heaped for burning. If much vegetation was present, windrows were made; however when there was only a light vegetation cover, it was usually pushed into separate heaps and burned . The windrowing and heaping operations at Bowenia were carried out with a bulldozer fitted with a blade. The cost of site preparation depended on the existing vegetation and the clearing and slash disposal techniques adopted. The average cost of clearing and burning using contractors in 1974/75 was $140 per hectare.

3.3.5. Nursery techniques

The nursery of Bowenia plantation covered an area of 1850m2 and produces approximately 250,000 seedlings per annum. The seed was sown into open beds in mid-april after a pre-treatement of six weeks in moist cold storage (-1°C to -4°C). Sowing was carried out in rows spaced 20cm apart using drills which distributed the seeds in rows and covered them with approximately 5mm of soil. Plants were then tubed at periods varying between 1 to 3 months after sowing. The tubed stock was then left in a bed prepared in the nursery until planted out in mid-december. In the 1974/75 financial year , the nursery costs were estimated to be $70 per thousand tubed stocks with the cost of tubing representing about 22 per cent of the total cost. Tubing was cheaper with 2 and 3 months old plants than with those one month old but lifting was cheaper with the younger plants. It was found that mid-March sowing following by late May and June tubing gave the best results at Byfield (Queensland Department of Forestry,annual report,1970).

3.3.6. Planting and Fertilising

Before planting, 290 kilogrammes of super-phosphate per hectare were applied to any site with a site index of less than 29. This application cost approximately $30 per hectare in 1974.

Planting of tubed stock began in mid-December and finished in June. A spacing of 2.7x2.4 metres was used. At that time, planting was done by hand but trials with open rooted stocks appeared to be satisfactory and the Department was hopefull that full scale planting of open rooted stock by machine would be feasible. In 1974/75, the cost of planting by hand was $45 per hectare, while the cost of machine planting was estimated to be $28 per hectare.

3.3.7 Tending

For the first five years, tending was carried out to ensure the succesful establishment and rapid growth of seedlings.

In the past, the removal of competing weeds was achieved by chemical or mechanical methods. Mechanical methods of weed control involve the use of cultivators, rotary hoes were only used on well prepared sites where the topography permitted. Manual methods are no longer widely used. During the second year, spray tending was undertaken by using a one per cent solution of 2,4,5-T in water as a folia spray and 1 per cent mixture in distillate as a basal bark spray. This mixture was applied to individual plants with a knapsack spray. During the third and fifth years, grass cutting was carried out mechanically along the rows and around each tree.

3.3.8 Fire protection and roading

Roading and Firebreak systems are essential to the management of forestry plantation. The road system, the length of roadway, and the firebreaks established in the plantation up till 1974 are given in Appendix 3.3. The firebreak system comprised external and internal firebreaks. External firebreaks were cleared and ploughed strips 60m wide with burnt buffer strips outside. The gross area was then subdivided into units of roughly 600 hectares by ploughing breaks 30m wide between the units. The units were then further subdivided into compartments of 70 - 100 hectares surrounded by roads 10 to 15m wide. Some of the firebreaks were also used as access roads to the plantation (See map 3).

In 1973/74, there was approximately 23 metres of roadway and 40 metres of firebreak per hectare in the plantation. In 1970/71 , the most recent figure available, the cost of road and firebreak construction was estimated to be $110 per hectare and the protection cost was estimated at $7 per hectare per annum.

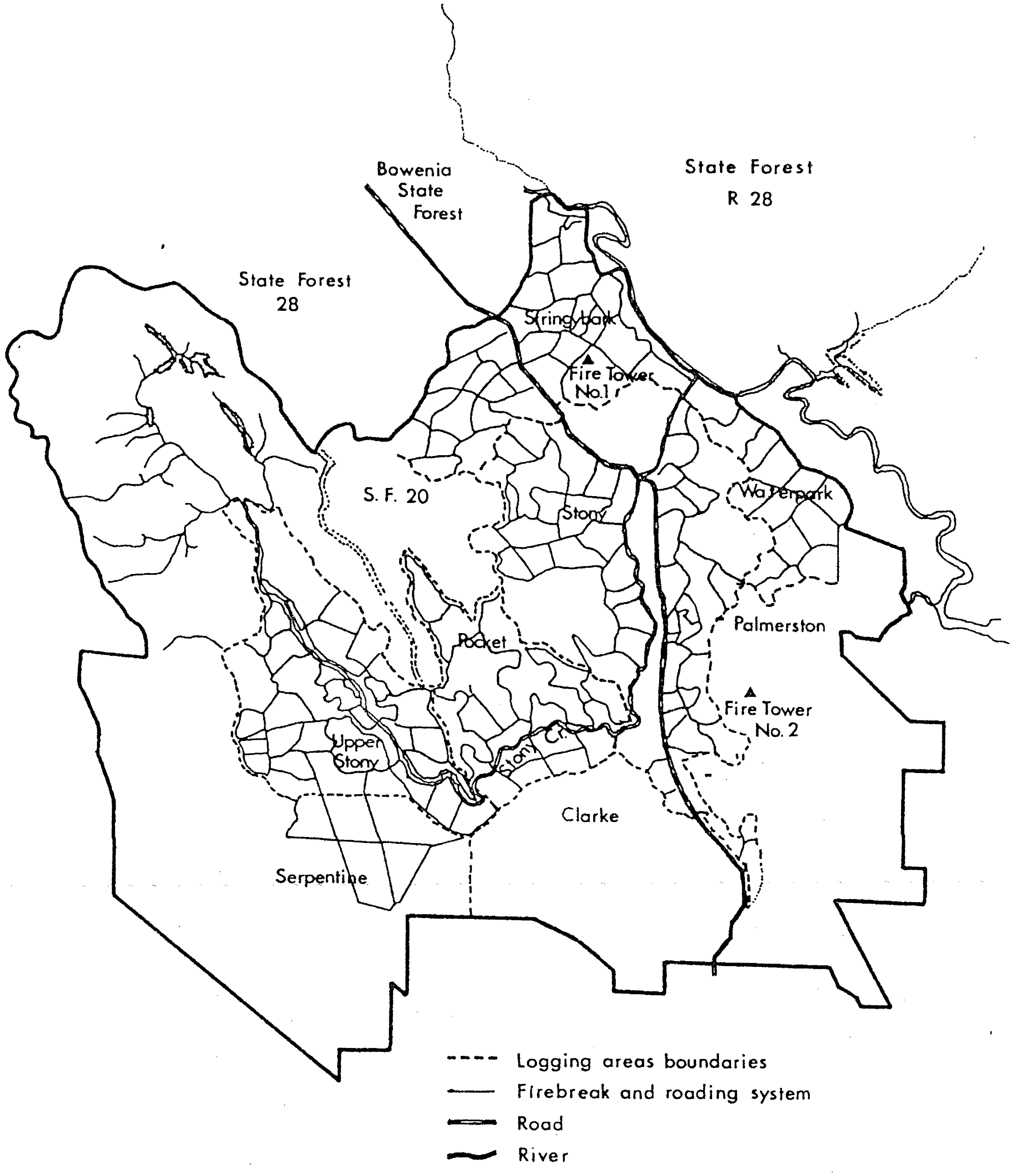
3.4 Management

3.4.1 Pruning

The pruning methods practised in the softwood plantations in Queensland were disigned to produce the maximum of high quality wood from either natural Hoop pine *Araucaria canninghamii* or exotic pine species and were described in detail by Robinson (1968) ,Hawkins *et.al.*(1968) and Hawkins (1971).

MAP 3

The Bowenia plantation at Byfield



Pruning of P.caribaea in the Bowenia plantation followed the general guidelines prescribed by the Queensland Department of Forestry. The aim of pruning was to achieve a final crop of 240 stems per hectare pruned to a minimum height of 7 metres and with a central knotty core of 15cm diameter. Trees were selected on the bases of vigorous growth, spacing and stem straightness to yield either a straight log of 5 metres or two logs of 2.5 metres long. Pruning was usually carried out during the winter season, May 1st to August 31st, on all areas with site index equal to or greater than 21 .

The pruning schedule for P.Caribaea in the Bowenia plantation was the same as that currently used for slash pine and was carried out when the trees were between 5 and 7 years old. The first pruning was not carried out unless 75 per cent of the stand is higher than 6m in height. The objective was to select 550 stems per hectare for pruning to a height of 2.5m above ground level. The second stage involved the selection and pruning of 300 stems to a height of 5m above ground level and the last stage was to select and prune 240 stems to a height of 7m above ground level. The second and third pruning were usually carried out in years 8 and 9 respectively.

3.4.2 Thinning

Hawkins et.al. (1968) described at length the techniques and methods of thinning used in the management of the exotic softwood plantations in Queensland . A premerchantable thinning to 988 stems per hectare at the average stand height of 3m or at age 5 to 7 years respectively was the general practice in 1974. This was in line with the policy which aimed to produce high quality sawlogs in the absence of a market for small pulpwood sized material. Generally, the stands were next thinned commercially, when the average stand height was approximately 16m. The stocking was reduced to either 700 healthy stems per hectare or a basal area of about 22m2 per hectare. A second commercial thinning from above was desirable five or six years later to retain a basal area of 21-25 m2 per hectare. An additional two to three further thinnings were envisaged before the stands were reduced to the best 240 selected stems per hectare.

In the bowenia plantation at Byfield the prime objective was to achieve the maximum production of quality sawlogs since there was no immediate prospects for a pulpwood market in the area. At the age of either 5 or 7 years, depending on the site and the vigour of the stands, unmerchantable thinning was undertaken to retain the best 988 stems per hectare. The first commercial thinning was then carried out at age 13 on area with a site index equal to or greater than 29 to a basal area of about 25m2 per hectare or approximately 740 stems per hectare. The direction of the first thinning was primary from above, to remove stems seriously competing with selected stems. The objective of the second thinning was to retain a basal area of 21 to 25m2 per hectare besides removing stems from above to ensure the dominance and maximum release of selected stems. This was usually carried out 5 years after the first thinning and was based on a minimum cutting diameter of 22cmDBH. Two or three subsequent thinnings resulted in the best 240 stems per hectare being selected for a final crop of good quality sawlogs with an average diameter breast height of 40cm at age 40 .

A second management schedule which included a havier unmerchantable to retain the best 740 stems per hectare was also included in this study. The first commercial thinning at age 16 was from above to retain 540 stems per hectare. Three subsequent thinnings resulted in a final crop of 240 selected stems per hectare at age 40 . Both of these thinning regimes are still somewhat conservative but were based on the objective and thinking in vague in 1974.

Table 3.2 and Table 3.3 show the two alternative thinning schedules for Pinus caribaea for a typical site index 29 stand.

The predicted yields from these thinning regimes were used to determine the revenues generated by the plantation development programme. The volumes estimated may be questioned because the plantation was still in the developmental stage and would need to be changed as further data on the actual growth rate of Pinus caribaea in the area becomes available .

TABLE 3.2
SAWLOG YIELD TABLE FOR PINUS CARIBAEA
IN THE BOWENIA PLANTATION
(Regime R1)
Site Index 29

Year	Pred.Ht	B.A.	Stocking after	Sawlog
-	(m)	(m2/ha)	thinning	(m3/ha)
16	22.30	9.48	543	41.90
21	26.50	7.40	419	47.60
27	30.20	8.50	296	69.40
33	32.90	4.45	244	43.70
40	33.40	35.65	0	416.45

1- Stand unmerchantably thinned to 988 stems per hectare at age 7

Source : Preliminary study , Queensland Department of Forestry, 1974 .

TABLE 3.3
SAWLOG YIELD TABLE FOR PINUS CARIBAEA
IN THE BOWENIA PLANTATION
(Regime R2)
Site Index 29

Year	Pred.Ht	B.A.	Stocking after	Sawlog
-	(m)	(m2/ha)	thinning	(m3/ha)
13	19.5	5.47	740	4.70
18	24.0	9.80	543	49.05
23	28.0	8.80	395	60.43
28	30.8	6.84	296	57.00
33	32.9	5.80	222	54.47
40	35.3	28.42	0	328.50

1- Stand unmerchantably thinned to 740 stems per hectare at age 7

Source : Preliminary study , Queensland Department of Forestry 1974 .

CHAPTER 4

THE ANALYTICAL FRAMEWORK

4.1 General

Cost-benefit analysis ,in its various forms, is most commonly used to evaluate government investment programmes such as land and water resources development, education, transport, city planning, and defence. In Australia, Cost-benefit analysis has been used to appraise a range of projects such as water supply schemes, irrigation proposals, and agricultural and forestry land development .

For many years the evaluation of development projects has been the major concern of investors irrespective of whether private or public funds are used.

The substantial development in economic analysis for public investment decisions has been discussed at length by many analysts, including Krutilla and Eckstein (1958); Dasgupta,Sen and Marglin (1972); Little and Mirrlees (1968); Marglin (1967); Mishan (1971); Prest and Turvey (1965); and Pearce(1971).

The main objective underlying the evaluation of most public investment projects is the desire to increase the total welfare of the population in the country as a whole. Welfare has traditionally been measured as the project's contribution to national income, net economic welfare or more commonly social net discounted revenue. Occasionally it has been measured by such secondary aspects as the multiplier effects generated on the national economy, balance of payments or the region's output, income or employment . Recognition of the objectives which the investor seeks to achieve is the first step involved in any analysis. These may be viewed over either short-term or long-term planning horizons . In the long-term, a governmemt or society may have the fundamental aim of maximising a population's satisfaction through increased living standards whereas in the short-term,(i.e. five to ten years), the government aims may include such things as achieving an increased production of a certain commodity or the raising of the level of exports of forest products to meet a particular market opportunity.

Projects can also be examined from a number of different levels according to the extent of their effects on a particular country's economy . The particular level chosen will influence the individual benefits and costs associated with the project, whether they are considered to have importance in the national interest or in the interests of a group of people in the region concerned .

Three levels of project evaluation are most readily identified although in Australia a fourth (the state) is also used. The three main levels are :-

a) National level

At this level, the measurement of the impact of the project's proposal on the total national economy which excluded the effects of internal transfer payments must be taken into account. All real costs and benefits generated within the economy that result from implementing the project should be calculated , whether direct , indirect, secondary or intangible. This level usually includes a careful consideration of the valuation of the inputs and outputs and may required the use of shadow pricing where market prices do not reflect the true cost or value of the inputs or outputs.

b) Regional level

This level covers the regional or local implications of the project and the welfare maximisation at this level is usually restricted to these people living in the region where the project is undertaken. The size of the "region" may be variable and could in Australia be extended to the whole state although this level should be examined separately. The assessement of any increase in the region's total social welfare, or redistribution of welfare between the different groups of people in the region becomes the testing criteria on a regional basis. For instance, if a forestry plantation is set up in any particular region, logging industries, sawmilling industries, or other wood using industries may form an essential part of that project in order to utilise logs produced by the plantation. Such associated industries normally generate additional employment and income within the region and their impact should be included in the analysis.

The costs and benefits relevant to the national and regional viewpoints may not coincide since some costs , such as nationally financed highways, which represent costs at the national level (particularly when financed from federal funds) would generate benefits at the regional level.

c) Individual level

At this level the effects generated by any project on an individual's personal income, way of life, or environment, are considered. Any costs and revenues of this nature which may be readily measured in the market should be included in the derivation of the project's profitability. This level is usually referred to a project evaluation.

4.2 The use of Cost-benefit analysis in Forestry

Land use decisions have became an important component of project evaluation and cost-benefit analysis because of the increased pressure on available land caused by population increases and rising living standards. In both the developed countries and the less developed countries the allocation of the few remaining areas of natural forests amongst competing land uses has became increasingly important, particularly where the production of forest products is of major regional or national importance.

The profitability of a forestry plantation development depends largely on the quality of soils, the location, and the choice of silvicultural regime which could either produce sawlogs or pulpwood products separately or a combination of the two. Government Departments, forestry companies and forest owners who are involved in the management of large scale plantations are usually committed to a long term capital investment programme before they receive returns from sales of raw materials (sawlogs or pulpwood).

However, one of the most important items of capital expenditure in forestry (because of the long-term nature of most forestry projects) is the expenditure on plantation development. It is essential that forest owners should carry out detailed feasibility studies of these types of investment programmes from both the national and regional viewpoint before committing scarce national funds and resources to them. Fortunatly both the developed and the less-developed countries are becoming increasingly aware of the need to make better use of their scarce national resources.

Cost-benefit analysis has been used in Australia since the 1960's, to evaluate projects ranging from the economics of land development in the Fitzroy Basin of Queensland (Holst Pellekaan,1964) ; determining land use alternatives in the Wide Bay region of Queensland (Cassidy et al.,1970) and water resources development (BAE,1973). Cost-benefit analysis is particularly useful for investigating the economic feasibility of forestry development projects where intangible factors are involved.

In Australia, Cost-benefit analysis has been recommended by the Commonwealth Treasury paper on Investment Analysis (Australia 1966) for use in evaluating forestry and other primary industry development programmes. Papers outlining the general principles involved in applying the technique of Cost-benefit analysis to forestry plantation programmes have been given by Leslie (1967,1971), Ferguson (1973a), Grut (1972), Watt (1973) and Ward,*et al.* (1966) .

4.3 Criteria

Three generally accepted criteria have been used in Cost-Benefit analysis to determine profitability. They are Net Discounted Revenue (NDR), the Internal rate of return (IRR), and the Benefit-Cost ratio (B/C). A brief description of each criterion is given below where as a more detail description and discussion of the three criteria can be obtained from Dasgupta,Marglin and Sen (1972), Gittinger (1973), Little and Mirrlees (1972), Mishan (1971), Merrett and Sykes (1974) and Prest & Turvey (1965).

4.3.1 Net Discounted Revenue

The discounted profit or NDR generated by a project is obtained by subtracting the discounted value of the costs stream from the discounted value of the stream of returns when each is calculated using the same discount rate(i) and base year. The NDR of a paricular project will therefore depend on the discount rate used and the nature and timing of the streams of costs and benefits over the project life.

In mathematical terms, the NDR of a series of n streams of costs and benefits with the first cost and benefit taking place year zero, at a discount rate i per cent is given by equation 4.1

$$NDR = \sum_{j=1}^{n} \frac{b_j}{(1+i)^j} - \sum_{j=1}^{n} \frac{c_j}{(1+i)^j} \qquad (4.1)$$

where NDR = Net Discounted Revenue;

bj = benefit in year j ;

cj = cost in year j ;

i = rate of interst ;

n = project life .

If the NDR is positive (i.e. discounted returns exceed discounted costs) the project is considered to be economically viable. This criterion enables the decision makers to determine the profitability a particular project or to choose between alternative projects when capital rationing does not occur. While this criterion provides a measure of the project's profitability in present value terms at the given discount rate it does not indicate the magnitude of the investment involved. On the other hand, it is a useful guide when the problem is to determine the optimum time to begin a particular project.

However, when calculating the social NDR the discount rate should be the social rate of time preference Grut (1972), Ferguson (op.cit) and Feldstein (1964b). Marglin (1963) argued that society is likely to have a different rate of time preference to that expressed in private or of an individual.

4.3.2 <u>The Internal rate of return</u>

The internal rate of return is the rate of interest which when used as a discount factor over the life of project, equates the present value of both the income stream and the expenditure stream. The internal rate of return is the positive solution i to the equation 4.2 when NDR is equal to zero.

$$\sum_{j=1}^{n} \frac{b_j}{(1+i)^j} - \sum_{j=1}^{n} \frac{c_j}{(1+i)^j} = 0 \qquad (4.2)$$

A project is economically desirable if the internal rate of return is greater than the relevant social or market rate of discount . As this criterion gives a measure of the productivity of capital and since the supply of capital is usually limited, the internal rate of return for various alternative investments is very useful when making investment decisions. Some analysts are in favour of the NDR because of the possibility of varying real discount rates over the life of the project whereas the internal rate of return is a uniform rate over all periods. However since there are no general rules for adjusting the discounting rate over time, and there are considerable problems involved in forecasting changes in real interest rates over time it is doubtful whether their arguments have practical significance. Of greater significance however is the possibility that a particular project may have multiple internal rates of return. One test for the existence of multiple roots is to determine the number of sign changes in equation supplied by Descartes (Turnbull,1952). Applied in the internal rate of return context, the number of positive solutions of an internal rate of return equation cannot exceed the number of changes in sign in the cash flows . Under these conditions the decision maker has to rely on the NDR criterion when making any decision although as Teichroew et al. (1965) pointed out the NDR criteria may also be mathematically inconsistent when this occurs. In water resources development and forestry projects, multiple solutions of the internal rate of return were unlikely as long as the cash flow pattern over the life of the project exhibited consecutive net cash deficits in the first few years, followed by a consecutive series of annual net cash surpluses (BAE,1973); (Fraser et al.,1977). Thus the project which has a negative value of cash flows during the earlier period of investment followed by the period of positive net benefits generated a unique solution for the internal rate of return.

4.3.3 The benefit-cost ratio

The benefit-cost ratio is the ratio of the discounted value of a project's return to the discounted value of its costs. To some extent the Benefit-cost ratio measures the efficiency of the use of capital in the project. The ratio which is sensitive to the discount rate used gives an indication of the desirability of a project. On most projects, an increase in the interest rate results a decrease in the Benefit-cost ratio. A project is economically desirable if the ratio is greater than one at the specified discount rate . If the borrowing rate for the project is used, the selection of projects will be influenced by the financing terms available rather than their relative economic impact. The Benefit-Cost ratio can also be expressed on different bases . For example, if operating costs are included in the denominator of the expression with capital costs the result expresses the return per dollar invested, whereas if the operating costs are subtracted from the numerator, the result expresses the return per dollar of capital invested. This ratio is very useful in determining the productivity of capital investment over time . This criterion which was widely used for revealing losses or gains on investment capital (Gittinger,1973);(Kuiper,1971) is now considered unsatisfactory.

4.3.4 Selection of the criterion for profitability

Although the three criteria described are not algebraically equivalent, each of them embodies the concept of discounting and discounted cash flow analysis and they do allow an investor to compare a project's income and expenditure over time.

The selection of the particular criterion that should be used when evaluating a project is difficult, since all three criteria are still subject to controversy. The advantages, disadvantages, and theoretical limitations of each of the criteria have been widely discussed in the literature. For instance, Mishan (1971) and Prest & Turvey (1965) are proponents of NDR while Merrett and Sykes (1974) advocate the use of an internal rate of return. The difficulty with the NDR technique and benefit-cost ratio in evaluating a project is that the calculation cannot be undertaken until the appropriate interest rate has been selected. The internal rate of return can be calculated without having to select an appropriate interest rate although one is necessary for determining whether a project is worthwile or not. However,when projects are considered by themselves, the NDR and IRR methods give the same results.

The NDR criterion is preferred when evaluating or selecting between alternative projects if there are no capital rationing. Where capital is limited, the NDR can misrepresent the true economic value of projects particularly when they differ markedly in size and capital requirements. The main disadvantage in the use of the internal rate of return is the possible occurrence of multiple solutions . However Gittinger (1973) stressed the usefullness of the internal rate of return in situation where the investor wished to make comparisons with other investment opportunities although when a direct comparison is made of mutually exclusive projects the internal rate of return can lead to an eroneous investment choice. The empirical study by Henderson (1968) showed that it is not necessarily correct to prefer the project which has a higher IRR. The IRR method may favour projects with relatively low levels of capital outlay or with returns in the early years of the project.

The three criteria cited above do not necessarily rank project in the same order of attractiveness. The ranking would depend on their projected time horizons and the cash flows of capital outlays, running costs and benefits. Although two projects may have identical capital costs, yields and time horizon, the ranking order given by the three criteria may differ simply because of differences in the pattern of cash flows over time. Although the internal rate of return had some disadvantages, it was one of the criteria used by the Asian Development Bank when evaluating the economic and financial viability of man-made plantation forestry in the less developed countries (Spears,1967).

The criterion most commonly used in forest economics and Land use studies in Australia is NDR (Gilmour and Reilly,1970); (Treloar and Morrison,1962); (Hoy and Sinden,1968); (Cassidy et al.,1970). The NDR is a function of the particular discount rate used and may not be a good indicator of land use profitablity unless the appropriate discount rate can be estimated accurately.

Traditionally, most evaluations of plantation forestry profitability, have been based on the Faustmann formula (Land expectation value) or some modifications of it. The formula is given in equation 4.3 (Hiley,1957) .

$$LEV_f = \frac{Y_n + \sum_a T_a (1+i)^{n-a} - C(1+i)^n - \sum_b P_b (1+i)^{n-b}}{(1+i)^n - 1} - \frac{e}{i} \qquad (4.3)$$

where LEV_f= Faustmann's land expectation value .

Y_n= Net revenue from clear felling in year n;

T_a = Net revenue from the thinning in year a, (a=2, ... ,n-1)

C = Establishment costs,

P_b = Silvicultural costs at year b, (b=2, ...,n-1)

e = Annual maintenance cost,

i = Interest rate,

n = Rotation length.

Basically, by imputing all surpluses to land, the Faustmann formula overestimates the economic value of land for forestry purposes. The formula in its original form indicates the maximum price that can be paid for land for forestry when the operator is prepared to accept a rate of return on capital equal to the rate of interest (i) . Grainger (1968) showed that the formula did not give the true economic worth of land in a major forestry plantation developed overtime because some costs are not included in the basic formula . These included the capital cost of roads, building and equipment which are not spread evenly over the development period and cannot be readily included in the formula either directly or indirectly in the annual maintenance charges. In addition the annual maintenance cost incorporated in the Faustmann formula is assumed to be constant whereas in fact this is not generally the case . The formula also implicitly assumes that land is the only factor limiting production and that capital is unlimited at the stated interest rate. The third assumption underlying the basic formula requires all areas of a project to be planted and managed from the beginning of year 1, and harvested at the end of the final year of the rotation. In practice, it is unlikely that this will be the case, especially where large-scale projects are involved. Parkes(1972) has suggested that more realism can be obtained for large-scale projects by the use of a modification which assumes the plantation is developed uniformly over the first rotation so that a sustained yield situation is reached by year n . The modification is given in equation (4.4)

$$LEV_{(sy)} = \frac{LEV_f}{n}\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] \qquad (4.4)$$

where LEV(f)= Faustmann land expectation value

i = discount rate

n = rotation length

The NDR of the project can be obtained from the LEV given above by subtracting from the LEV the actual cost of the land as follows:-

$$NDR = LEV - L$$

where L = the actual cost of the land.

This assumes that all land is purchased at the beginning of the first year of the plantation development.

Ferguson (1973a) suggested the Net Social Benefit (NSB) was more appropriate criteria than the NDR when evaluating forestry project for commercial wood production because it allows the costs and benefits of the project to be shadow priced .

While any of the three criteria could have been used the NDR criterion was selected to examine the economic profitability of plantation development from the Queensland Department of Forestry viewpoint . The NSB was used when evaluating the project from the national viewpoint. This criterion was able to test the basic aim of the study which was to examine the economic profitability of plantation development under plantation management practices in use in 1974. The NDR and the NSB were calculated using a computer programme which discounted the cash flow for the first rotation back to the base year (1974) . These were added to the discounted costs and revenues for all subsequent rotations from year n to infinity (i.e. from year 2014 onwards, discounted, in each case, back to the same base year 1974 . The point of evaluation of the output in the NDR and the NSB calculation of the plantation development was at the stump .

The formula used in this study are presented in equation (4.5) and (4.6) :

$$NDR = NDR_f + R / (1+i) \qquad (4.5)$$

and

$$NSB = NSB_f + R / (1+i) \qquad (4.6)$$

Where

NDR_f = the NDR for the first rotation ($/ha);

NSB_f = the NSB for the first rotation ($/ha);

R = The discounted net worth in year n of the subsequent rotations from year n to infinity ($/ha);

i = denotes the discount rate;

n = rotation length.

where

$$NDR_f \text{ or } NSB_f = \sum_{0}^{j} \sum_{t=1}^{t=n} \frac{P_{jt} V_{jt}}{(1+i)^t} - \sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t} \tag{4.7}$$

$R = TR_{n+1} - TC_{n+1} / i$

V_{jt} = denotes the volume of jth product at age t;

P_{jt} = denotes the prices of the jth product at age t;

C_t = denotes the establishment costs at age t;

TR_{n+1} = denotes the total revenue at year n+1;

TC_{n+1} = denotes the total costs at year n+1.

4.4 Valuation of the inputs and Outputs

Cost-benefit analysis requires quantification of the costs and benefits during each year of a project's life. The costs and benefits of the project were classified according to the purposes of evaluation. Prest and Turvey(1965), Sewell et al. (1965) and Jensen (1968) have discussed the classification of costs and benefits whereas Leslie (1971) discussed at length the costs and benefits associated with most forestry development programmes. Costs and benefits were classified as being either primary or secondary depending on whether they are received by the initiator of the project or not. In some projects, it is particularly difficult to identify secondary costs and secondary benefits correctly. To overcome the problems of measurement of secondary benefits, Eckstein (1961) suggested the "with and without" principle, in which economic development with and without the project is compared. The secondary costs and secondary benefits which result from the project being implemented can then be identified .

The direct costs and benefits of the Bowenia forestry plantation to the Department of Forestry were obtained and used later in the economic analysis based on both the national and the regional viewpoint.

The direct costs associated with the Bowenia project were broken down into establishment costs, equipment costs, wages and salaries, maintenance and other operating costs. The benefits from the project were derived from the sale of logs. The costs and benefits included in the cost-benefit analysis from the Queensland Department of Forestry viewpoint are described in Chapter 6, while for the social cost-benefit analysis they are discussed in Chapter 8.

4.4.1 Shadow pricing

Most economic evaluations of forestry projects have been based on the market valuation of costs and benefits. However, because of government intervention and other market imperfections market prices need not represent the true social value of inputs and outputs ,particularly when resources are fully employed in the economy and the mobility of factors is restricted. When market distortions or externalities cause distortions in the market prices of the costs and benefits of a project, then adjustments must be made to the market prices. Little and Mirrlees (1968) stated that when calculating a project's net social benefit shadow prices of costs and benefit should be used because they are a more accurate measure of social costs and benefits than market prices. Ferguson (1973a,1973b) supported the use of shadow prices for sawntimber and capital when deriving Net Social Benefit for wood production in forestry.

A number of different ways of calculating the shadow prices of products has been suggested most of which have been outlined by Little and Mirrlees (1968) .

4.4.2 Intangibles

The intangibles associated with any project included those costs and benefits which are not fully measurable in money terms or which may not be satisfactorily expressed in monetary terms. Some benefits from forestry projects may be non-marketable but will often be important considerations in project evaluation. These benefits include such things as watershed protection, soil erosion control, recreation, flood control, and beautification of the landscape. Obviously,direct quantification of these costs and benefits is difficult. The costs can be estimated as an opportunity cost of lost production by imposing whatever environmental requirements are necessary as constraints. However, methodological work covering the quantification of any non-wood benefits through the market machanism is very limited. Ferguson and Greig (1973) showed that certain intangible benefits such as recreational use of forests could be measured and were expressed as opportunity costs. The value of preservationist and environmental considerations remains largely a matter of subjective judgment .

While the intangible benefits can be important in forestry project they were not evaluated in this study of the Bowenia plantation because of the limits imposed by the scope of the study and the limited time period.

4.4.3 Secondary benefits

The secondary benefits are defined as the increase in the values of goods and services which indirectly result from the project . Measurement is based on the conditions expected to occur as a result of the project as compared to those without the project.

To date, few forestry evaluations in Australia have incorporated indirect effects because they are very difficult to estimate accurately. Reilly (1974) has shown how relatively simple economic base models may be used to analyse the indirect effects of forestry in an Australian situation.

Ferguson (1974) has used input-output analysis to estimate the secondary effects generated by the establishment of a wood chip industry in Western Australia .

Douglas (1974 and 1978) has used the national input-output model to compare the wage income multiplier effects of forestry to those for three forms of agricultural land use and the regional input-output model to estimate the income multiplier effects of forestry in Central Queensland. Although these studies indicated that the secondary effects were considerable they were not able to be evaluated because of the limitations already discussed.

4.4.4 The treatment of taxes and subsidies

The financial analysis includes the effects of taxes and subsidies which have became directly incorporated in the market prices of the inputs and outputs. In the social cost benefit analysis however taxes and subsidies were regarded simply as transfer payments and their effects have been subtracted from the prices of goods or added to them to obtain the true social worth of the inputs and outputs. However because the Bowenia plantation represents a very small percentage of the state government's costs and revenues and as taxes and subsidies cause little if any distortions to the price of plantation forestry inputs/outputs market prices were used without adjustment as being reasonable measures of costs and benefits accruing to the Bowenia project.

4.5 The choice of discount rate

A survey of the relevant literature indicated a considerable diversity of opinion in regard to selecting the appropriate interest rate for use when evaluating forestry projects. The literature covering both the theory and practice of discounting techniques has interpreted the discount rate variously as the cost of capital , the opportunity cost rate available on alternative investments, or the rate of time preference relevant to the project.

The social opportunity cost rate (S.O.C.R.) which is the rate of interest funds could earn in alternative uses, is considered by Baumol (1967) and Feldstein (1964c) to be appropriate for using in analysis of public investment. This argument is based on the premise that state investment is displacing private investment because state funds are obtained through loans, taxes and tariffs from private individuals or enterprises. In a perfectly competitive world, the social opportunity cost of these funds could be represented by the market rate of interest; but in practice no single interest rate can fully measure the social opportunity cost of such funds.

The rate of time preference refers to the rate of discount which relates the value of a dollar's worth of consumption now at time (t) to its value to a consumer at some date in the future (t+1). The social rate of time preference (dt) therefore is a measure of society's marginal rate of substitution of consumption in year t+1 for consumption in year t (Feldstein, 1964a). He defined the social rate of time preference (dt) applicable between years t and t+1 as :-

$$dt = M.R.S._{t+1,t} - 1 \qquad (4.8)$$

Feldstein (op.cit) indicated that the social rate of time preference (dt) in equation 4.8 is implicitly determined by the current level of consumption and its rate of growth.

Feldstein(1964a) concluded that the social rate of time preference is more relevant in determining the discount value of costs and benefits of social investments because it is the rate which society uses to relate present and future consumption opportunities.

Using the social rate of time preference as a discount rate creates two difficulties; firstly, it is very difficult to calculate accurately (Little and Mirrlees,1968) although it can be calculated from the intertemporal marginal rate of substitution (equation 4.8) provided the government's target economic growth rate and the consumption has been adopted and the rate of investment required to achieved it and the consumption level at a particular time are specified (Watt, 1973). This method of derivation is open to criticism because as Watt indicated that target rate of growth ought to be derived from the social rate of time preference and not vice versa. In addition the relationship between the rate of investment and the rate of growth is not precisely known (Watt,1973). Consequently, the choice of S.R.T.P. has to be made between different combinations of the growth rate, investment rate and time preference rate. The second problem with the social rate of time preference is that it may not remain constant over time or with changes in the level of consumption within a given time period (Feldstein,1964a).

A number of researchers have used the long-term government borrowing rate arguing that this is the cost of capital to the government. However, because of the institutional factors in capital markets, the government borrowing rate does not represent a true market rate nor is it completely risk free.

Neither method provides a completely satisfactory way of determining the discount rate. The choice of a discount rate is therefore extremely difficult in particular when evaluating a forestry plantation project largely because the relevant rate will depend on the circumstances facing a potential investor. The fact that imperfections invariably exist in most capital market further complicates the issue. Any prospective borrower is faced with a wide range of market interest rates and the existence of market imperfections make the determination of a risk-free, real rate of interest extremely complex.

If future costs and future benefits have been valued at real prices, the real rate of interest should be used (Grut,1972). This requires the removal of the effects of inflation by using the relationship given in equation (4.9)

$$(1+f) = (1+r)(1+i) \quad (4.9)$$

which on rearrangement gives

$$r = (f-i)/(1+i)$$

$$\text{or } f = r+i$$

where f = financial rate of discount

r = real rate of interest

i = rate of inflation.

In practice a considerable range of interest rates have been used when evaluating projects. In the United Kingdom a standard discount rate of 10 per cent is used for all cost-benefit analysis (Perry,1974). In France, the discount rate used is 7 per cent (Schleicher,1973) while the Commonwealth Treasury of Australia considered a discount rate of 5 or 6 per cent was appropriate for evaluating public projects(Australia,1966) but in recent times this rate has been increased. During the 1960's, interest rates of 5.5 per cent were commonly used when evaluating land development and water supply schemes.

Leslie(1971), used a rate of interest of 5.5 per cent when evaluating investment which was undertaken primarily for timber production. Leslie based this rate on the uncertainty and risk associated with the long economic horizon involved. In New Zealand, Ward et al. (1966) used interest rates of 4, 5 and 6 per cent for the Maretai studies of Forestry development while Fenton et al. (1968) used interest rates of 5, 7 and 10 per cent. The New Zealand Treasury currently requires new government investments to have internal rate of return higher than 10 per cent (N.Z. Forest service, 1974). Grut (1972) adopted discount rates of 8,10 and 12 per cent for softwood plantation evaluation under South African conditions. Discount rates of 5, 6 and 7 per cent were used in North Queensland for deriving Land expectation value in Pinus Caribaea plantation (Gardner, 1970). Cassidy et al. (1970) used three separate discount rates of 5,5.5, and 6 per cent in the simulation and cost-benefit evaluation of land use in forestry in South East Queensland. Ferguson (1973a) also used a discount rate of 5 per cent for the calculation of Net Social Benefit in a Victorian forestry project based on wood production.

In Australia, the average level of inflation over the period 1970/71 to 1974/75 measured by the Consumer Price Index was 11.3 per cent per annum. The average long term bond rate, over the same period, was 7.5 per cent. Consequently any funds lent at the long term bond rate during this period would have been earning a negative real rate of interest of approximatly -3.6 per cent. When evaluating development projects (i.e. forestry) which are normally long -term, the discount rate used should be based on the expected long-term trend in interest rates. The rather sharp increase in the rate of inflation in Australia in recent years was considered to be a short-term phenomenon by many economist and planners . They believed that in the long-term interest rates would remain relatively stable while inflation was expected to decline .

During the period 1959/60 to 1968/69, the long-term bond rate was remarkably steady at about 5 per cent per annum while the rate of inflation was also fairly stable increasing at an avarage rate of 3.4 per cent per annum . The real long-term bong rate of return on government bonds was therfore 1.55 per cent over this period. This rate is unrealistically low and reflected goverment control over the major lending institutions and its use of a tight fiscal and monetary policy.

While private investments are generally selected on the basis of maximising profit regardless of the externalities they create public project have usually been selected because of the multiple benefits and objectives they achieve such as providing employment and welfare to a particular region. Therefore the Bowenia plantation project being a public undertaking is not necessarily under the same pressure to make as high profit as a private investment although Leslie (1971) questioned this argument. Consequently, the selection of an appropriate interest rate to discount future costs and revenues from the Queensland Department of forestry viewpoint and the social viewpoint presents problems. In this study, the long-term government bond rate between 1959 and 1969 of 5 per cent was considered realistic for use as a discount rate from the Department's viewpoint. The 5 per cent rate which is often used in analyses of forestry data is approximately the rate payable by the Queensland Department of Forestry on loans from the Federal government .

However, to examine the sensitivity of the results to variations in the interest rate a range of discount rates ranging from 3 per cent to 8 per cent per annum were used when calculating the NDR from the Queensland Department of Forestry viewpoint . The upper limit of the discount rate approximates the 7.5 per cent real rate of return after tax earned by Australian manufacturing industry over the ten financial years (1962/63 to 1972/73). However, the upper level rate of 8 per cent might be considered conservative when compared with the financial market rates which have been offered on the market in recent years. The 3 per cent rate was used as the lower limit, because approximates the risk free real government bond rate.

The social rate of time preference which reflects society's consumption preference over time was used when evaluating the project from the national viewpoint.

Baumol (1868) argued that the real yield on government bonds should be regarded as the lower limit of the social rate of the rate of time preference because those who do not buy bonds have a higher preference for comsumption than those who do buy them. Ferguson (1974) stated that although the exact rate is still subject to debate it is somewhere between 4 and 6 per cent. Dasgupta and Pearce (1972) suggest that the social rate of time preference may be about 4.5 per cent in the United Kingdom. Ferguson (1974) adopted the median value of 5 per cent . Hence , the rate of 5 and 6 per cent were used in the evaluation of the project from the social viewpoint .

4.6 Scope of the study

The primary purpose of this study was to determine the viability of the project for wood production in the region. This use may conflict with other possible alternative uses such as water catchment , National Parks, Wildlife conservation, etc. However these alternative uses were outside of the scope of this study.

CHAPTER 5

THE PRICES OF SAWLOGS

Wood production revenues while being directly related to the stumpage prices paid for sawlogs normally own some 30 to 40 years in the future. Therefore , the estimation of future prices of sawlogs is an important component in a profitability analysis of a plantation development programme. Two methods of deriving stumpage values were considered in this study and are described in this chapter. Firstly, when considering the viewpoint of the Queensland Department of Forestry , the relevant prices for use in the analysis were the actual sawlog prices received by the Department of Forestry for logs sold in the Rockhampton market in 1974. These prices were derived from the stumpage appraisal assessments. However, the stumpage appraisal method of valuing the output of the forest from the Department of Forestry's viewpoint did not necessarily represent their true social value for the social cost-benefit analysis. For this reason, a second approach which was based on the shadow prices of sawntimber imported into the Rockhampton market was used. The social price of wood valued at the stump were then calculated from the import shadow price for the Bowenia plantation at Byfield. Little & Mirrlees (1972) have argued that import prices are usually representative of the true social value than domestic prices. Domestic prices of sawlogs may be regarded as being somewhat artificial because they have traditionally been by direct negotiation between the Department of

Forestry and the Sawmiller's Association, although some account is taken of local market forces. The Sawmiller's Association exerts monopoly control over the sawntimber market in the Rockhampton area so to some extent sawntimber prices are not subject to the free play of market forces but are more indicative of monopoly control. This situation seems unlikely to change in the future unless competition from imports increases.

Until 1974 the supply of sawntimber, poles and sleepers from the local forests were just able to satisfy local demand within the Rockhampton region. However between 1963/64 and 1973/74, the supply of sawlogs from native forests declined slightly (see Chapter 2), but is expected to level off at the 1974 level for the next 25 years (FORWOOD,1974). Population growth and industrial development within the region (Department of Northern Development,1974) are expected to cause demand to exceed local sawlog supply which excludes the estimated sawlog supply from the Byfield plantation, under its present rate of development by some 30 per cent by the end of this century . Imports of sawntimber into the region will be necessary to offset the anticipated shortfall in demand unless a faster rate of plantation development is carried out. It is unlikely that any shortfall in the local supply of forest products within the Rockhampton region can be met by supplies from other parts of Queensland because Queensland as a state has also not been able to satisfy its local demand for forest products from domestic resources.

As increasing quantities of imported sawntimber come into the region price setting for locally produced sawntimber will become less monopolistic and more competitive. Hence, the price of imported forest products should play an increasingly important role in determining both local sawntimber and stumpage prices.

Until 1975, native sawntimber, both hardwood and softwood, supplied the bulk of the Rockhampton market. Although _Pinus caribaea_ sawntimber can not meet all of the physical and mechanical properties of hardwood, there are still a considerable number of uses where _Pinus caribaea_ can be substituted satisfactorily. Preservative treatment to improve the durability of sawn _Pinus caribaea_ will extent its usefulness for building purposes even further.

The limit amount of research into the mechanical and physical properties and strength ratings of _Pinus caribaea_ undertaken by the Building Materials Division of C.S.I.R.O. indicated that while it is inferior to old growth _Douglas fir_ from North America it is equal to if not better than second growth _Douglas fir_ and _Pinus radiata_ . The research indicated strength rating of F4 for _Pinus caribaea_, second growth _Douglas fir_ and _Pinus radiata_ compared to F5 for old growth _Douglas fir_ respectively. However, more recent tests indicated that close to 40 per cent of the sawn _Douglas fir_ imported from New Zealand had a strength rating below F5 so that it is at best comparable to _Pinus radiata_ and _Pinus caribaea_ or possibly of lower strength rating (Prologue, 1976).

Buick(1969) found that over 80 per cent of the Kiln dried framing timber produced from 35 years old trees of Pinus radiata consisted of F4 metric stress grade or better and would satisfy the code specifications in standards requirements of framing sawntimber. He indicated that the variability in strength in Pinus radiata could be traced to knot defects. However, most knot defects can be removed through appropriate cultural thinning, pruning and tree breeding.

The limit amount of information which is available on the mechanical and physical properties of locally grown Pinus caribaea sawntimber indicates that it should be satisfactory for use as a structural timber(Groves, 1976,pers.comm.). Pinus caribaea has already been used in wood truss manufacture in Southern Queensland and Smith (1973) indicated its desirability over slash pine for use in pulpwood.

Pinus caribaea appears to have the same strength rating as Pinus radiata so sawn timber produced from the Pinus

Footnotes:

(1) F4 is measured the Modulus of rupture (bending and strength) 5600 - 7100 lb/sq.in.

(2) F5 is measured the modulus of rupture (7110 - 8000 lb/sq.in.)

caribaea plantation at Byfield should be capable of meeting the building code requirements for structural sawntimber and should be technically be able to substitute for both imported second growth Douglas fir and Pinus radiata sawntimber in the building industries for the Rockhampton region in the future .

Mill grade studies on Pinus caribaea sawlogs carried out by the Queensland Department of Forestry (Table 5.6) indicated that on average 40 per cent of the sawntimber output would be in selected grade, 20 per cent of utility grade and 31.7 per cent of standard grade. Clear grade and joinery grade made up 8 per cent of the total. Provided that the log qualities are similar to those used in the mill studies then some 70 per cent of the sawntimber produced from locally grown Pinus caribaea should be suitable for use in the building and construction industries.

5.1 Imports of Sawntimber

The major sources of supply of Queensland's sawntimber imports are New Zealand,Papua New Guinea, Malaysia and the United States of America. Klinki pine and Meranti are imported from Papua New Guinea and Malaysia while Douglas fir is imported from New Zealand,the United States and Canada. Imports of softwood sawntimber from New Zealand and the United States increased steadily over the period 1965 to 1975. Imports of Douglas fir sawntimber from the United States increased from 5937 m3 in 1965 to 10466 m3 in 1975 while imports of Douglas fir sawntimber from New Zealand rose from 3624m3 in 1965 to 5673m3 by 1975.

Imports of Kauri pine and Klinki pine sawntimber from Papua New Guinea declined steadily over the same period falling from 7945 m3 in 1971 to only 2204 m3 in 1974. Figure 5.1 shows the patterns of Queensland's imports of sawntimber by country between 1963 and 1975 while Table 5.1 shows the pattern of imported sawntimber into Queensland by species .

TABLE 5.1

IMPORTED SAWNTIMBER INTO QUEENSLAND

BY SPECIES, 1965-1975

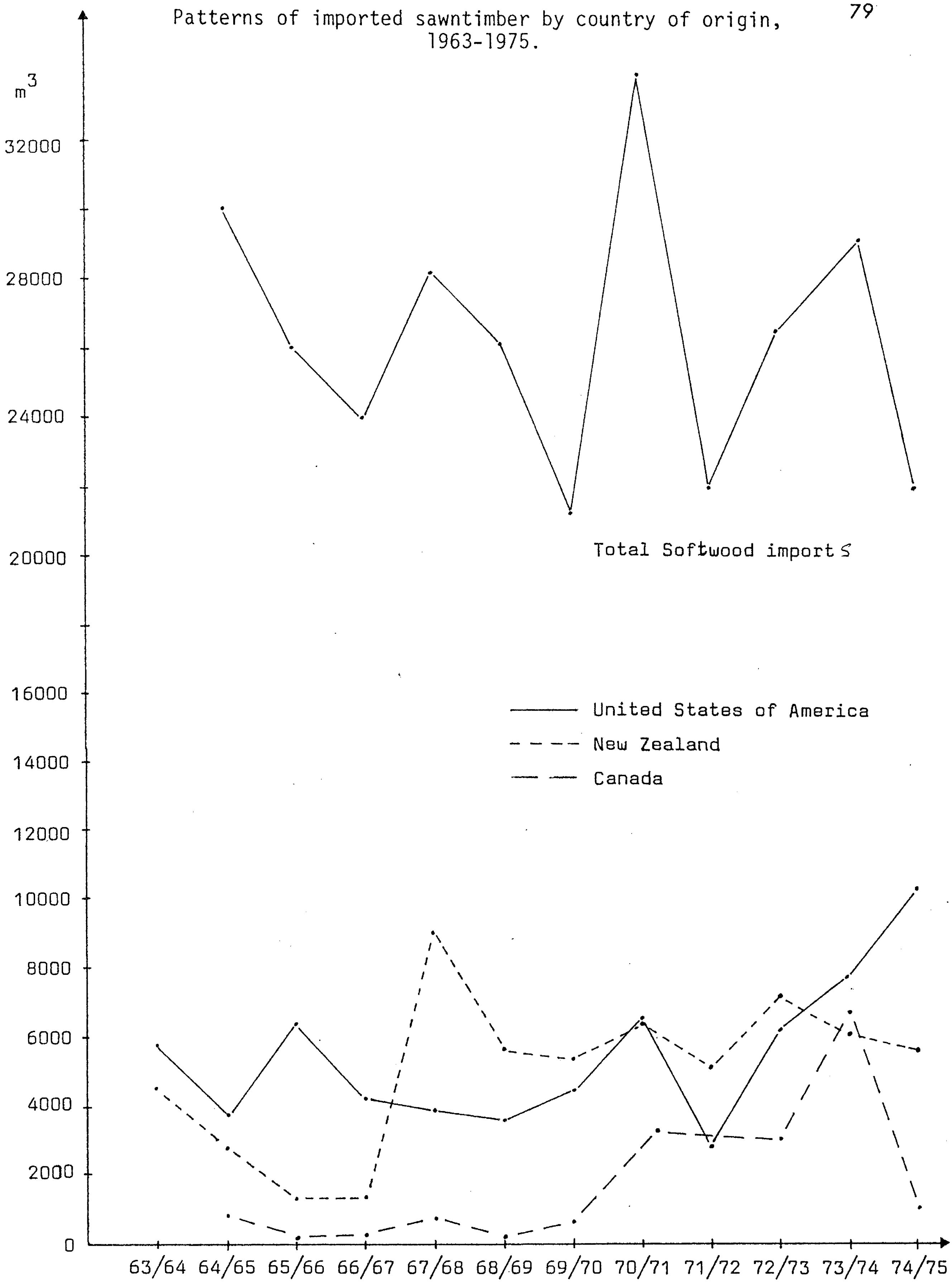
(cubic metres)

year	Douglas fir	Radiata pine	Others	Total
1965/66	3461	2966	23605	30032
1966/67	5538	1411	18404	25353
1967/68	3497	1326	19170	24041
1968/69	6886	2133	19427	28446
1969/70	6357	665	18231	25254
1970/71	5654	809	23044	21453
1971/72	11629	486	4934	34049
1972/73	8797	703	12252	22177
1973/74	14156	335	11406	25899
1974/75	16174	1031	12667	29872
1975/76	13979	1141	7894	23014

Source: Timber supply review

Figure 5.1

Patterns of imported sawntimber by country of origin, 1963-1975.



5.2 Domestic Prices of sawntimber

Local sawntimber prices are principally determined by the Rockhampton market. The trends in structural sawntimber prices over the period 1963/64 to 1975/76 were given in figure 5.2. In 1973/1974, the average price of indigenous hardwood sawntimber in the Rockhampton region was \$96.00 per m3. Between 1963/64 and 1975/76 the wholesale prices of Cypress pine and Natural pine (Hoop and Bunya pine) sawntimber rose from \$50.8 per m3 to \$113.4 per m3. Sawntimber prices of both natural pine and Cypress pine increased by an average of 9.12 per cent per annum between 1963/64 and 1975/76. The rate of increase followed two distinct trends. From 1963/64 to 1971/72, the average annual increase was 2.85 per cent per annum which was slightly below the rate of inflation. However, from 1971/72 to 1975/76 prices increased sharply averaging 18.76 per cent per annum. Prices of indigenous hardwood sawntimber and plantation thinnings followed much the same pattern as those of natural and Cypress pine over the same period. Between 1963/64 to 1971/72, hardwood sawntimber prices increased by an average of 3.41 per cent per annum and the corresponding rate for plantation thinnings was 2.7 per cent. Between 1971/72 to 1975/76, prices increased by an average 18.04 per cent per annum. Sawntimber price indices of the three native timbers and plantation thinnings are given in Figure 5.3

Figure 5.2

Wholesale prices for sawntimber in South Queensland, 1963/1964 - July 1975.
(Current values)

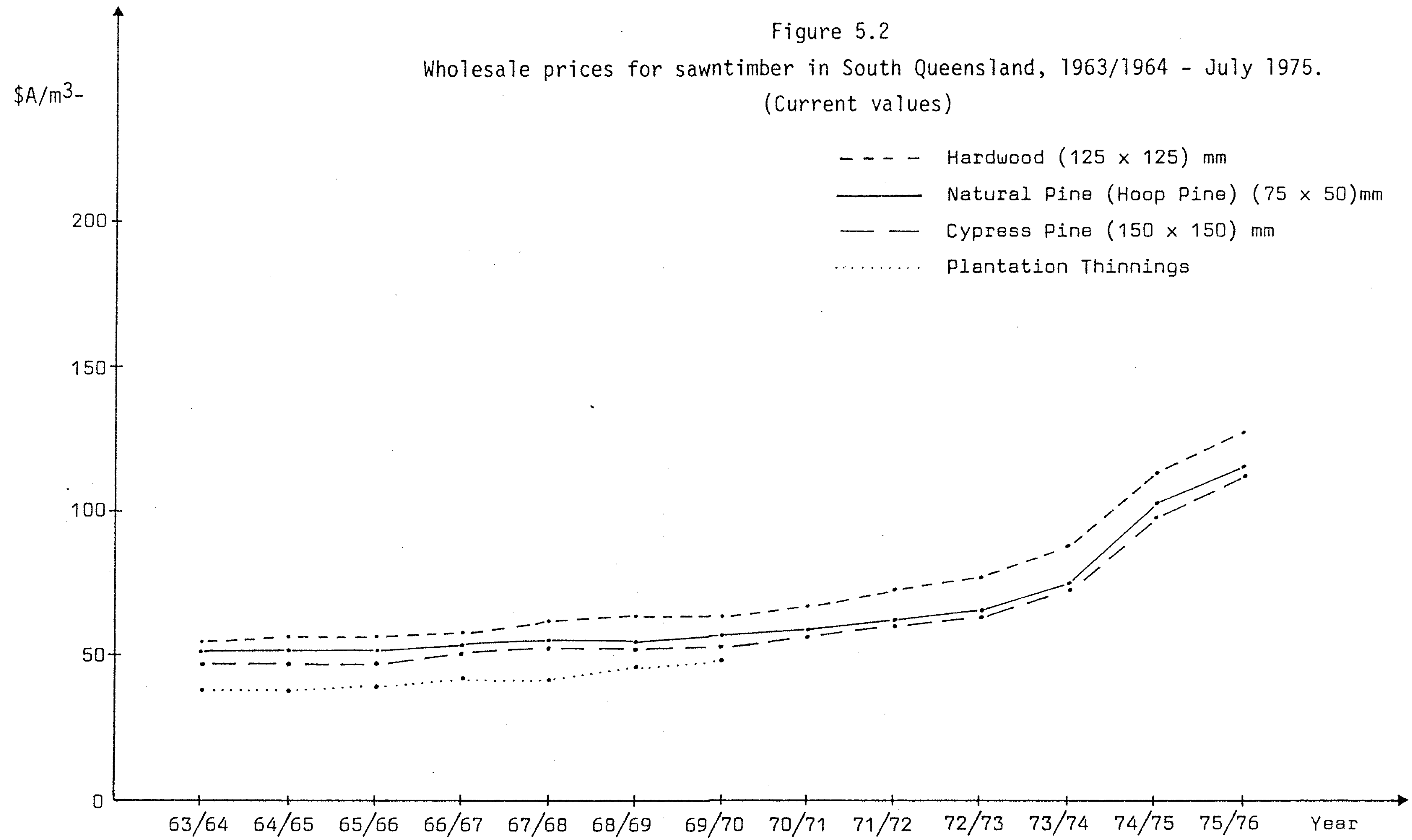
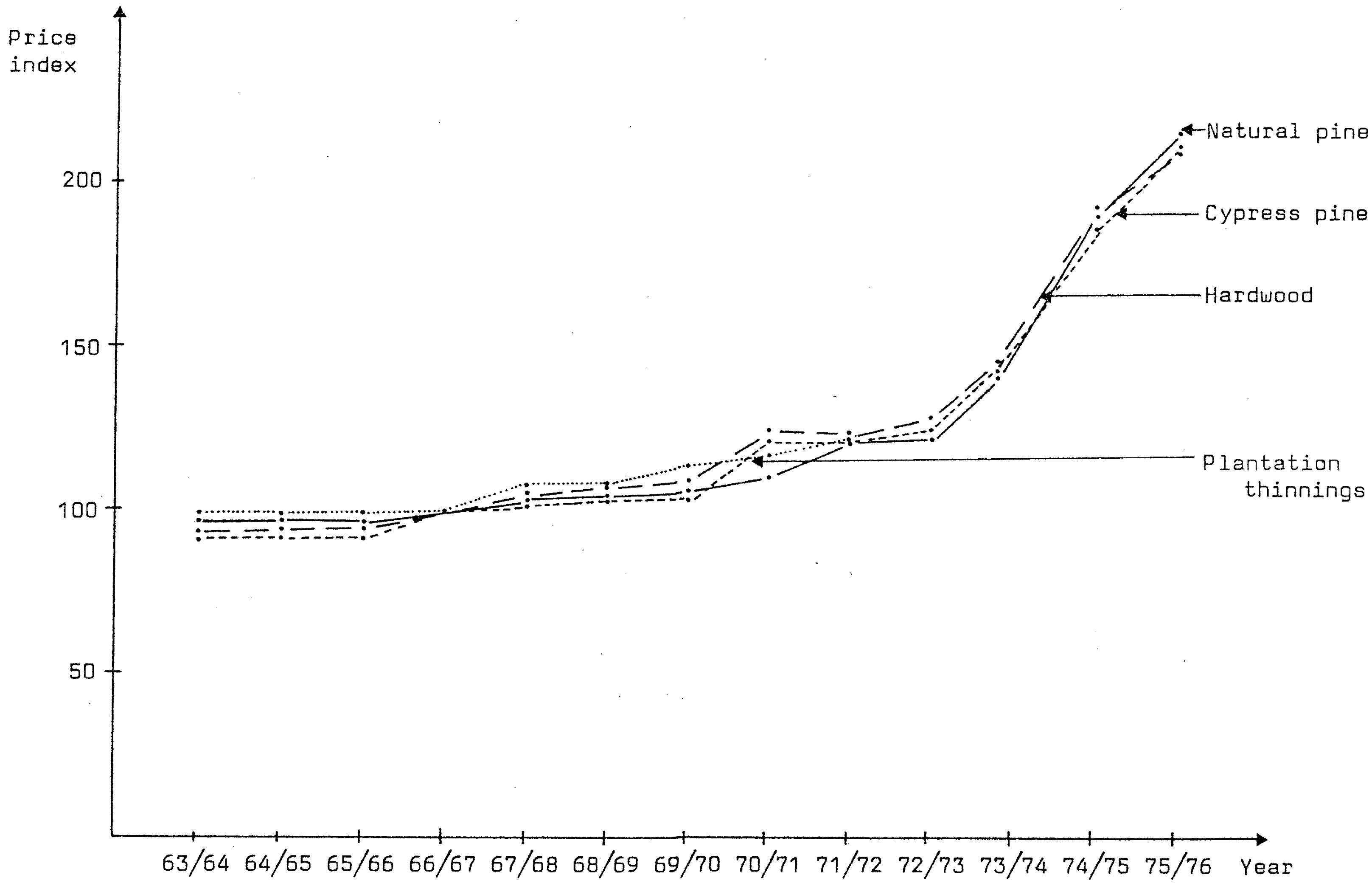


Figure 5.3

Wholesale prices indices of indigenous sawntimber and plantation thinnings in South Queensland (1966-67 = 100)



5.3 International Market Prices of sawntimber

The price of softwood sawntimber imported into Queensland were derived from three major suppliers, the United States, New Zealand and Canada. These three countries are the major exporters of Douglas fir to both Queensland and Australia and are likely to hold this position at least till the end of the century. The major market in Australia for Douglas fir is in house framing. The f.o.b. price of imported Douglas fir sawntimber between 1960/61 to 1974/75 is given in figure 5.4. The f.o.b. price of Douglas Fir imported from the United States increased from $40.95 per m3 in 1960/61 to $75.85 per m3 in 1975/76(there was a decrease of $14.67 per m3 between 1973/74 and 1974/75). During the same period, the f.o.b. price of Douglas fir sawntimber imported from New Zealand rose fairly steadily from $34.83 per m3 to $81.82 per m3, while the f.o.b. price for Canadian exports of sawn Douglas fir for the corresponding period rose from $37.83 per m3 to $82.60 per m3. The annual rate of increase in sawntimber prices between 1960/61 and 1971/72 averaged 1.9 per cent per annum for timber from the United States and 3.0 per cent for timber from New Zealand. For the period 1971/72 to 1975/76 the average annual price increase rose sharply to 29.7 per cent for the the United States and 26.6 per cent for New Zealand. Figure 5.5 gives the Douglas fir price indices for sawntimber imported from the three supplying countries over the period 1960/61 to 1974/75.

Figure 5.4

Average f.o.b. prices of imported Douglas fir sawntimber from the United States, New Zealand and Canada, 1960/1961 - 1974/1975.

(Current values)

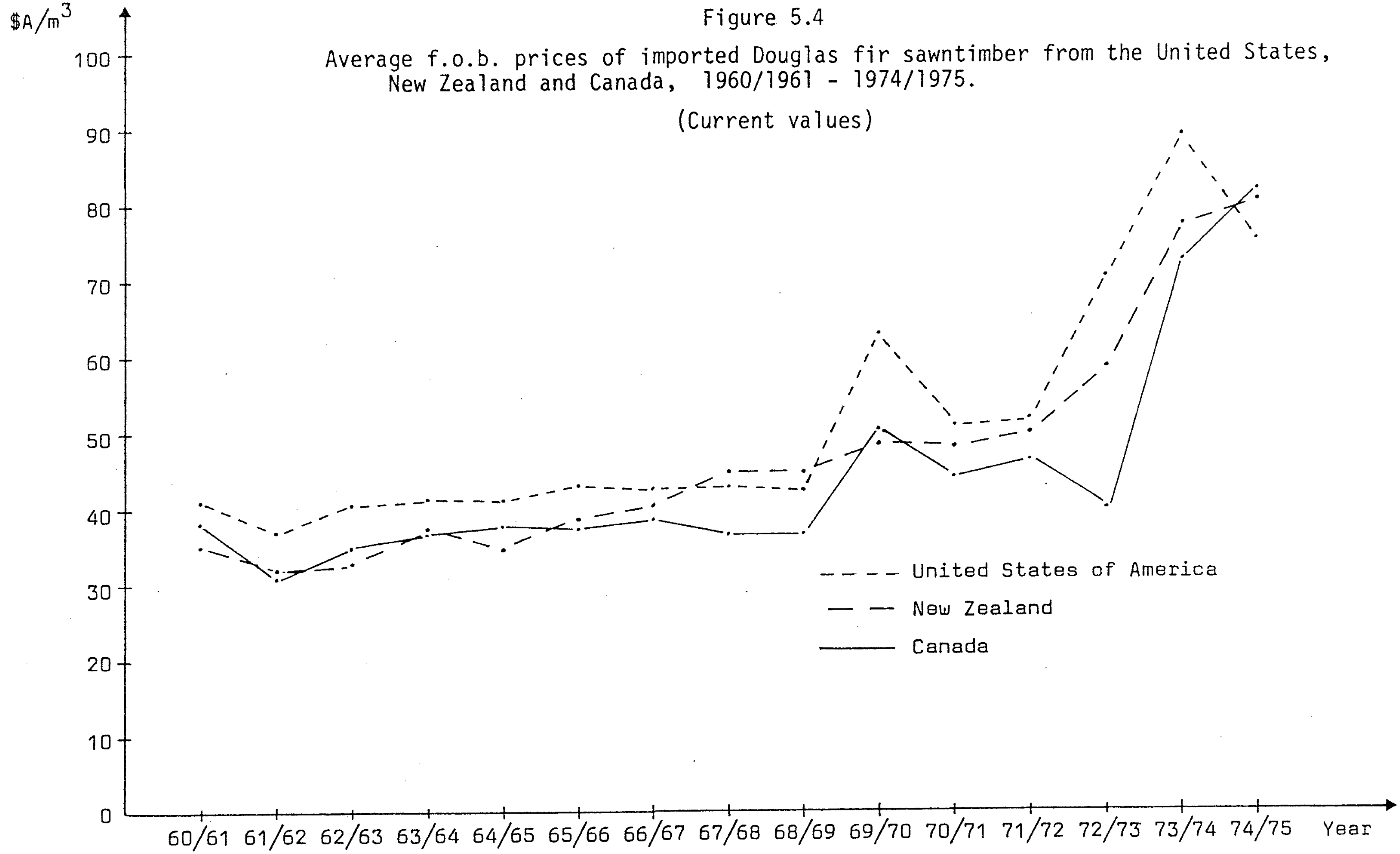
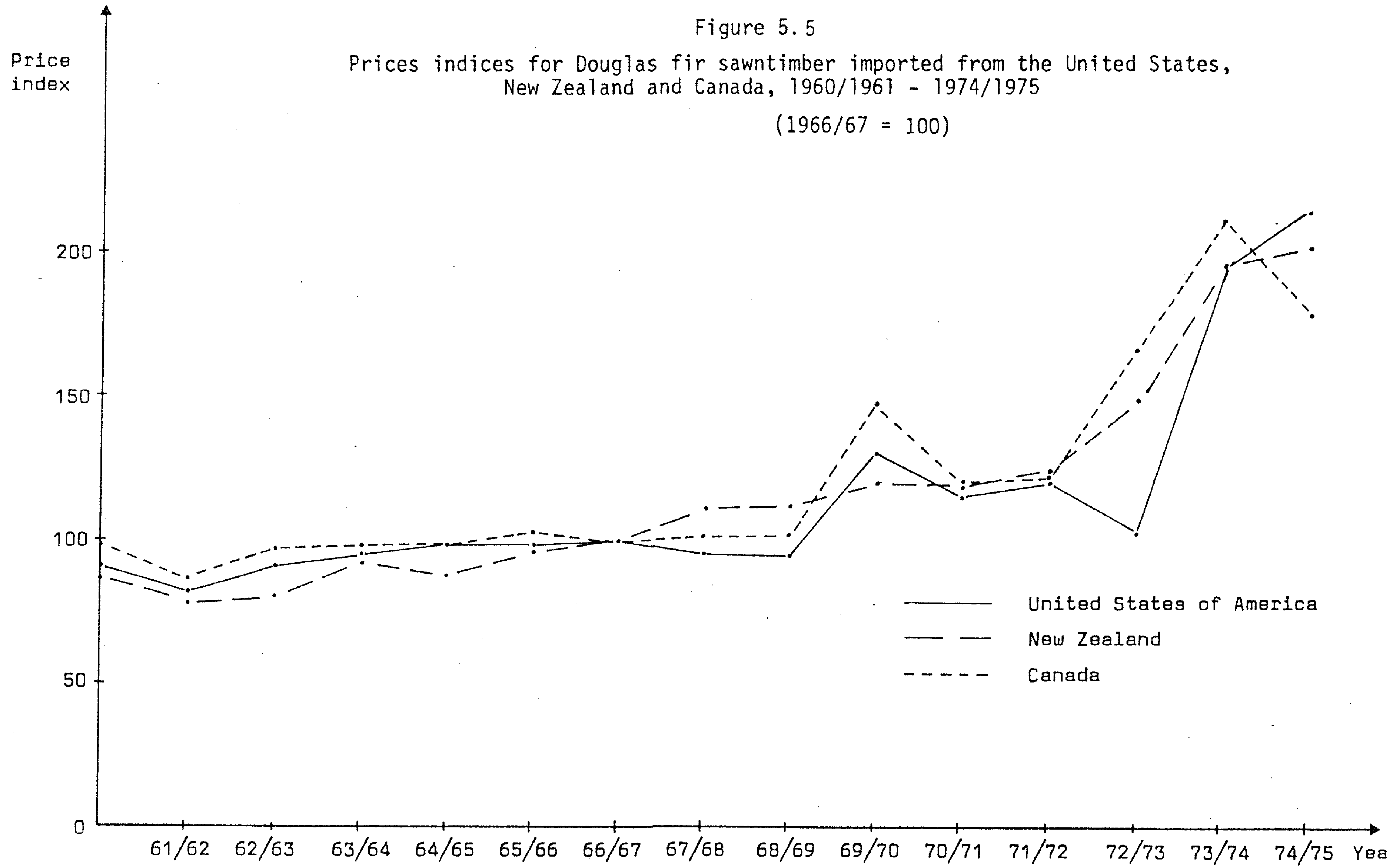


Figure 5.5

Prices indices for Douglas fir sawntimber imported from the United States, New Zealand and Canada, 1960/1961 - 1974/1975

(1966/67 = 100)



The historical increases in the prices of both locally produced and imported sawntimber have had an important influence on the profitability of local forestry plantations. The Forwood report (1974) forecast an increase of 15 per cent in the real price of locally produced sawntimber in Australia between 1974 and the year 2000, using 1974 as the base year. This represents an average rate of increase of 0.6 per cent per annum in real prices. Douglas fir sawntimber from the United States was and probably will be the major species exported to Australia . Therefore, the future prices of sawntimber imports will also influenced by the domestic sawntimber prices in the United States

Wholesale prices for construction grade framing Douglas fir in the United States have increased at 1.00 per cent per annum in real terms since 1953/54 (Reilly,J.J. 1976, pers.comm.). From 1910 to 1970, stumpage prices of Douglas fir rose an average 3.5 per cent per annum (USDA,1973) while sawntimber prices have risen even more rapidly(USDA,1973). Based in part on past trends in relationships between stumpage and product prices shown by a number of recent studies, it has been assumed that an average of about 75 per cent of future increase in timber product prices would go to stumpage. The remaining of 25 per cent of product prices increases would be available to cover high costs of harvesting and manufacture (USDA,1973) .

In this study, five price levels of sawntimber were analysed in determining the residual values of sawlogs at the the Bowenia plantation at Byfield :-

1. The average actual price received by the Queensland Department of Forestry for sawlogs sold in 1974 was used to calculate the plantation stumpage revenue for the departmental viewpoint.

2. Prices are assumed to remain constant in real terms (i.e. stumpage prices will not rise faster than other product prices).

3. The price level of imported Douglas fir sawntimber in 1974 from the United States was assumed to be the "most likely" assumption for deriving the shadow residual values of sawlogs in the social cost- benefit analysis.

4. The price level in 1974 of Pinus radiata sawntimber imported from New Zealand was assumed to be the "likely" assumption for deriving the shadow residual values of sawlogs in the social cost-benefit analysis.

5. And the market price of indigenous sawntimber in Rockhampton was assumed to be the lower limit for deriving the shadow residual values of sawlogs in the social cost-benefit analysis.

5.4 Residual values for the Cost-Benefit analysis from the Queensland Department of Forestry viewpoint.

The prices charged by the Department of Forestry in 1974 for logs at the Rockhampton market were considered to be the most suitable for use in the evaluation of cost-benefit analysis from the Departmental viewpoint.

The Pinus caribaea upset prices in the Rockhampton key markets obtained from the log price list were used to derive the stumpage value of sawlogs for the Bowenia plantation. Present plantation management utilises an early thinning to waste to either 740 stems per hectare or 988 stems per hectare between age 5 and 7 years. In order to determine which regime gives higher profitability two residual values at stump based on different thinning schedules were used in this analysis. Table 5.2 gives the residual values of sawlogs per cubic metre true volume measure to 15cm top diameter under bark (TDUB) at stump of the regime R1 with initial stocking of 740 stems per hectare at age 16 . The corresponding figures of the regime R2 with a stocking of 988 stems per hectare at age 13 were presented in Table 5.3 .

5.5 Residual Values for Social Cost-Benefit Analysis

As both the State of Queensland and the Rockhampton region appear likely to be net importers of sawntimber well into the future, the landed sawmtimber prices at Gladstone of Pinus radiata from New Zealand and Douglas fir from the United States were used as a basis for shadow pricing. All relevant costs (as at 1974)-freight rates, insurance,processing costs and transportation costs were deducted to give the import substitution shadow prices at the stump.

TABLE 5.2

RESIDUAL VALUES OF SAWLOGS AT STUMP OF PINUS CARIBAEA

FROM THE BOWENIA PLANTATION UNDER REGIME R1

under regime (R1).

(per m3 true measure to 15cm TDUB).

Thinning Age	PRED.HT (m)	DBHOB (cm)	Residual value of sawlogs
	-	-	($/m3)
16	22.3	24	5.45
21	26.5	26	7.03
27	30.0	29.9	9.15
33	32.9	33.0	9.58
40	33.4	43.0	16.96

TABLE 5.3

RESIDUAL VALUE OF SAWLOGS AT STUMP OF PINUS CARIBAEA

FROM THE BOWENIA PLANTATION UNDER REGIME R2

(per m3 true measure to 15cm TDUB).

Thinning Age	PRED.HT (m)	DBHOB (cm)	Residual value of sawlogs
-	-	-	($/m3)
13	19	22	4.15
18	24	26	7.03
23	28	28	8.33
28	31	30	9.26
33	33	31	9.37
40	33+	40	15.84

The formula used in calculating the residual values of sawlogs is as follows :-

$$S = (Fi + f + w + s - s' - M)Ri - Li \quad (5.1)$$

where S = the shadow price of sawlogs at Byfield based on the import replacement value of sawntimber (1973/74 value per m3);

Fi = denotes the f.o.b. price of sawntimber of Douglas fir or Pinus radiata which locally grown Pinus caribaea sawntimber is going to compete with (1973/74 values per m3);

f = denotes the cost of shipping freight and insurance (dollars per m3);

w = the cost of wharfage, wharf handling, harbour dues, quarantine and storage (dollars per m3);

s = the freight cost of tranporting sawntimber from Gladstone to Rockhampton market (dollars per m3);

s' = the freight cost of transporting sawntimber from the mill at Yeppoon to Rockhampton (dollars per m3);

M = the cost of sawmilling (dollars per m3 of sawntimber);

Ri = the recovery factor for sawntimber cut from sawlogs of size class i (per m3 sawn volume);

Li = the logging costs in dollars per m3 log volume;

The shadow prices derived from equation 5.1 need not necessarily represent the true social value of sawlogs in the region if local supply conditions alter drastically. Although sawntimber imports have been increasing over time, a dramatically expanded plantation development programme could produce an over supply situation in the region in the future. If this did occur the sawlogs or sawntimber which are surplus to local requirements would have to either compete with existing hardwood supplies or be sold on the export market. Under these circumstances, the social prices for the output of a plantation development proposal could well be less than the duty-free import replacement prices. However, as this is not likely to occur at the planting rate examined and as the real price of sawntimber imports will probably increase in the long term (Ferguson,1974), the use of import replacement values based on constant 1973/74 prices is likely to underestimate the true social value of plantation forestry over time.

5.5.1 Shadow prices of sawn Douglas fir and sawn Radiata pine

The average f.o.b. prices for sawn Douglas fir imported from the United States and for sawn Radiata pine from New Zealand were \$78.59 per m3 and \$50.40 per m3 respectively in 1973/74 (ABS,1974c).

Gladstone, which is situated about 135 km from Rockhampton, is an important port for exporting coal in the Rockhampton region and is the logical port for landing sawntimber for the Rockhampton market. Freight rates from the United States to Gladstone were not available.

Consequently, the freight rate of $35.52 per m3 from New Zealand to Brisbane based on data supplied by the Union Bulk Ship Pty. Ltd. and Associated Steamships Pty. Ltd. (1975,pers.comm.) was used in this study. The freight rate for timber carried from the west coast of the United States to Gladstone would probably higher , and result in a higher landed prices than that based on the New Zealand to Brisbane freight rate which was used. By adding $8.24 per m3 for harbour dues,wharfage, wharf handling, storage, insurance and quarantine costs, as shown in Table 5.4, the shadow prices were obtained for sawn Douglas fir and Radiata pine landed at Gladstone. The resulting shadow prices were $128.01 and $99.82 per m3 respectively.

5.5.2 Residual value of sawntimber at mill-door.

The residual value of sawlog at mill-door per m3 of sawn outputs were obtained by subtracting transport costs of sawntimber from the Rockhampton to Yeppoon and sawmilling costs from the Rockhampton sawntimber shadow prices. The sawmilling costs used were based on those of a hypothetical sawmill established at Yeppoon as described in the next section. The residual value of sawlogs at mill-door (sawn volume basis) for Douglas fir, Pinus radiata and Indigenous species were estimated to be at $99.61, $71.42, and $66.93 per m3 sawn respectively and are presented in Table 5.4. Table 5.5 gives the estimated sawlog prices at mill-door per m3 log volume volume basis by diameter class (D.B.H.).

TABLE 5.4

RESIDUAL VALUE OF SAWLOGS AT MILL DOOR BASED ON THE COST OF IMPORTED SAWN DOUGLAS FIR, PINUS RADIATA, AND INDIGENOUS SPECIES, 1973/74

(in dollars per m3 sawn)

Items	Sawn Douglas fir ($/m3)	Radiata pine($/m3	Indigenous species ($/m3)
1 Imported prices (F.O.B.)	78.59	50.40	-
2 Freight rates	35.52	35.52	-
3 Harbour dues	0.60	0.60	-
4 Wharfage cost	0.80	0.80	-
5 Wharfage handling cost	4.45	4.45	-
6 Storage cost	0.05	0.05	-
7 Insurance	1.72	1.72	-
8 Quarantine cost	0.62	0.62	-
Landed prices at Gladstone	122.35	94.16	-
Transportation costs from Gladstone to Rockhampton	5.66	5.66	-
Shadow prices of sawntimber at Rockhampton	128.01	98.82	93.33
9 Transport cost to Yeppoon	2.80	2.80	2.80
10 Sawmilling costs	25.60	25.60	25.60
11 Residual value of sawntimber at mill-door	99.61	71.42	66.93

TABLE 5.5

RESIDUAL VALUES OF SAWLOGS AT MILL DOOR BY DIAMETER CLASS BASED ON THE COST OF IMPORTED SAWN DOUGLAS FIR,PINUS RADIATA AND INDIGENOUS SPECIES, 1973/74.

per cubic metre log volume

D.B.H. (cm) -	Recovery Factor %	Douglas fir ($/m3 log volume)	Radiata pine ($/m3 log volume)	Indigenous species $/m3log vol.
19-24	23.2	23.10	16.56	15.52
24-29	38.3	38.15	27.35	26.63
30-34	46.8	46.62	33.42	31.35
34-39	46.8	46.62	33.42	31.25
40+	50.0	49.80	35.71	33.46

5.5.3 Sawmilling costs

Sawmilling costs for a medium sized softwood sawmill were not available from the Rockhampton region. A sawmill is currently being established at Yeppoon to saw the output of the Bowenia plantation at Byfield. Consequently sawmilling costs are based on a hypothetical mill using a band saw headrig working one shift per day for five days per week. The annual sale of sawlogs from the Bowenia plantation was estimated to reach a maximum allowable cut per annum of 24,000 m3 by 1984, based on the present rate of planting. When the plantation reaches the sustained yield development by the end of this century , the estimated output of sawlogs from the Bowenia plantation will be approximately 120,000 m3 per annum. The size of the hypothetical sawmill used to estimate the sawmilling costs was sufficiently large to be able to saw the maximum future output of sawlogs from the plantation. In practice, the mill would be designed to allow room for future expansion in order to cope with the increased output , probably in two stages. Data used for estimating sawmilling costs were based on the study of the utilisation of the southern pine of the United States (Reilly,1971) and on sawmilling costs used in the land use study of the South coast in New South Wales (Reilly,J.J. 1976,pers.comm.). The hypothetical sawmill was assumed to have an annual log intake of 120,000m3 per annum. The average cost of production for this type of sawmill was based on a direct labour cost of 31.5 per cent of total costs with indirect costs making up the balance.

Labour inputs were based on sawmills in the southern United States(Reilly, 1971) where it was estimated that an average of 3 man-hours were required to produce one cubic metre of sawnwood.

The above estimate of labour inputs cost at the average earning rate of $2.68 per man-hour (ABS,1974b) gave an estimated sawmilling cost of $25.6 per m3 of sawntimber.

5.5.4 Sawn recovery factor

Sawntimber recoveries for the hypothetical sawmill outlined in the previous section, were assumed to be the same as the sawn recoveries obtained from mill studies carried out by the Queensland Department of Forestry ,annual report(1973). Sawn recoveries, from the mill study , vary from 23.2 per cent to 50.00 per cent (actual green sawn volume over actual log input volume. In Australia,sawn recoveries appear to be of the order of 0.40m3 to 0.45 m3 green sawn volume per m3 log volume (Reilly,J.J. 1976,pers.comm.). For Pinus caribaea, the sawn recovery of 0.46m3 sawn per m3 log volume can be achieved when the log has a diameter greater or equal to 30cm diameter breast height (DBH).

It is expected that the recovery percentage would increase if stem straightness can be improved through tree breeding and better silvicultural practices such as pruning, thinning . A range of sawlog sizes processed by the hypothetical mill was expected to vary from 22cm to over 40cm DBHOB, variations in sawn recovery by log diameter were included in the analysis.

The recoveries given in Table 5.6 were used in this study :

TABLE 5.6

PERCENTAGE DISTRIBUTION OF SEASONED SAWNTIMBER RECOVERED FROM PINUS CARIBAEA LOGS IN MILL STUDIES CARRIED OUT BY THE QUEENSLAND DEPARTMENT OF FORESTRY

(as a percentage)

SI 29 and 31

D.B.H. (cm)	Clear Grade+	Joinery Grade+	Select Grade+	Standard Grade+	Utility Grade+	Percentage Recovery
19-24	-	-	42.0	20.3	37.7	23.2
24-29	5.9	1.8	36.8	27.3	28.3	38.3
30-34	6.0	1.5	42.8	32.8	16.9	46.8
34-39	1.8	0.7	29.8	46.4	21.3	46.8

+AS 0108,1969.

Source: Queensland Department of Forestry

5.5.5 Extraction costs

The cost of extraction depends upon the particular techniques and equipment used. The costs of extraction used in this study were those obtained from the Queensland Department of Forestry using a four wheel drive tractor for snigging. Hauling was assumed to be carried out using seven tonnes capacity trucks and trailers. The total extraction costs of *Pinus caribaea* in the Bowenia plantation for 1973/74 is presented in Table 5.7.

TABLE 5.7

FELLINGS AND EXTRACTION COSTS OF PINUS CARIBAEA

IN THE BOWENIA PLANTATION 1973/74

D.B.H. (cm)	PRED.Ht. (m)	EXTRACTION COSTS ($/m3 log volume)
19-24	18 - 20.9	10.57
24-29	21 - 23.9	9.66
30-34	24 - 26.9	9.19
34-39	27 - 29.9	8.90
40+	30 - 32.9+	8.90

Souce : Queensland Department of Forestry , 1974.

5.5.6 Shadow stumpage prices of sawlogs

The social shadow price of *Pinus caribaea* sawntimber will depend on its ability to substitute for *Pinus radiata* or *Douglas fir* sawntimber. The higher price implicitely assumes that *Pinus caribaea* will effectively substitute for *Douglas fir* and the lower price assumes that it will substitute only for *Pinus radiata*. The residual stumpage based on the local indigenous price of sawntimber was also examined because *Pinus caribaea* sawntimber will have to compete with to some extent in the Rockhampton region. The residual stumpage values of sawlogs are presented in Table 5.8 and were derived by substituting the relevant values in Equation 5.1 .

TABLE 5.8

STUMPAGE PRICES OF SAWLOGS AT BYFIELD BASED ON THE COST OF IMPORTED DOUGLAS FIR FROM THE UNITED STATES PINUS RADIATA FROM NEW ZEALAND AND INDIGENOUS SPECIES IN ROCKHAMPTON, 1973/74

($/m3)

D.B.H. (cm)	Douglas fir ($/m3)	Pinus radiata ($/m3)	Indigenous species ($/m3)
19-24	12.53	5.99	4.96
24-29	28.96	18.16	16.44
30-34	37.72	24.52	22.35
34-39	37.72	24.52	22.35
40+	40.90	26.81	24.56

CHAPTER 6

COSTS AND REVENUES FROM THE DEPARTMENTAL VIEWPOINT

The data upon which the cost estimates of the plantation project being studied were based were supplied by the head office, the Rockhampton sub-district office and also the Byfield plantation office of the Queensland Department of Forestry. Costs in this case comprised both direct and indirect field expenditure. For the Cost-benefit analysis from the Queensland Department of Forestry viewpoint, data obtained from the Forestry Department were used to estimate the cost of equipment used during the development of the plantation. Labor costs were based on the wages and salaries paid to forestry workers employed in the field.

6.1 COSTS

Direct and indirect expenditures on the project were readily available in monetary terms. Easily identifiable costs included field expenditure(direct labor and overhead costs) , Capital improvements, equipment running costs, materials and maintenance costs and equipment costs.

6.1.1 Field expenditure

Field expenditure costs included the direct labour costs given in Appendix 6.1 and overhead costs . The overhead costs (indirect) include Public holiday pay, annual leave, sick leave, wet time, travelling time and tools. The indirect costs were estimated from the number of working hours lost during the operations. The total field expenditure was then calculated from the actual man-hours worked in each type of operations (one man may be employed on several different operations during the course of a year) . The labour requirement in man years per hectare was calculated for each operation assuming that each man normally worked only 1225 hours per year with 855 hours lost to overheads. Because the physical data on labour input was not available the financial data had to be used to calculate the number of man-years employed in the development phase each year. The formula used to calculate the man-year labour requirement for the Bowenia plantation is given in Equation 6.1 and the the results of the calculations are given in Table 6.1

$$\text{Number of man-year/ha} = W/(Wa \times t) \quad (6.1)$$

where :

W = wage cost per hectare (Base-year= 1974)

Wa = Average wage rate per hour ($2.30/per ha in 1974)

t = Number of working hours per year.

Table 6.1 shows that the annual labour requirement for plantation establishment (surveys,cultivation,clearing, planting, plants at site, fertilising and roading & firebreaks) accounted for an average of 39 per cent of the total labour requirement for developing the plantation.

TABLE 6.1

ANNUAL LABOUR REQUIREMENT BY TYPE OF OPERATIONS FOR THE DEVELOPMENT OF THE BOWENIA PLANTATION BASED ON A PLANTING RATE OF 200 HECTARES PER YEAR
(man years)

Types of operations/year:	1	2	3-4	5-6	7	8	9-10	11-12	13-40
Surveys	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Cultivation,Clearing sites	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Plants at site	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Planting	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26
Fertilising	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Roading & Firebreaks	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35
First tending	-	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Second tending	-	-	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Third tending	-	-	-	0.72	0.72	0.72	0.72	0.72	0.72
First Pruning	-	-	-	-	-	2.67	2.67	2.67	2.67
Second Pruning	-	-	-	-	-	-	2.58	2.58	2.58
Third Pruning	-	-	-	-	-	-	-	2.58	2.58
Thin to waste	-	-	-	-	1.45	1.45	1.45	1.45	1.45
Total	16	16	17	18	20	23	25	28	29

The labour requirement per year for silvicultural operations (tending, pruning and thinning) made up approximately 38 per cent of the total. The balance of 23 per cent covered the labour input on roading and firebreak contruction and maintenance.

The average base year (1974) wage for forestry employee of $48ØØ was used to calculate the total field expenditure costs of the Byfield plantation development and presented in Table 6.3 .

6.1.2 <u>Capital improvements.</u>

Capital improvement costs covered the costs of building and fire equipment. Building costs included expenditure on housing for the plantation employees, general offices, single men barracks, garage/workshop and storeroom. Most of the capital improvements occured during the first year of development. One fire tanker and equipment was also purchased in the first year but the other two were purchased in the 4th and the 25th year of development. The initial capital improvement costs were estimated to be $66,4ØØ and the cash flow of these costs over the development stage is presented in Table 6.3.

6.1.3 <u>Equipment costs</u>

The annual expenditure on equipment covers the cost of heavy equipment (tractors), light vehicles, rotary hoes, ripper, plough, chainsaws, harrow discs etc. used in the plantation. The unit cost of equipment was calculated on the basis that it was fully employed throughout the year. The purchases of equipment were spread over time through the development stage (40 years). To achieve the most efficient use of the equipment, four tractors(two two wheels drive tractors and two four wheels drive tractors), 7 light vehicles, 7 chain saws, 2 ploughs, 1 ripper and 1 rotary hoes were needed to carry out all operations for the development of the plantation. The purchase schedule of equipment for the Bowenia plantation was based on the actual and forecast purchase schedule supplied by the Queensland Department of Forestry (1974,pers.comm.) details of which are given in Appendix 6.2. Straight line depreciation of all equipment was adopted (Appendix 6.3) and at the end of its economic life its scrap value was assumed to be 15 per cent of the initial purchase price.

6.1.4 Equipment running costs and Materials

The cost of fertiliser and other materials and equipment used for tending , pruning and thinning (which included pruning tools and paints) were included under the annual running costs. The 1974 costs of fertiliser and materials were estimated to be \$7.65 and \$16.40 per hectare per year respectively. The annual running costs of all motor vehicles and tractors in the Bowenia plantation were based on the 1974 figures supplied by the Queensland Department of Forestry (1975, pers. comm.) and are given in Appendix 6.4. These costs were subdivided into Fuel, Oil, Tyres , repairs and maintenance costs.

6.1.5. Indirect costs

Indirect costs comprised administration costs and local office expenditures.

The local office expenditures included the wages of the mechanic, storeman, drivers, carpenter, clerical, supervisory and miscellaneous staff which were responsible for the day to day management of the plantation. These costs were based on man-years equivalents and the corresponding total costs over the development phase are given in Table 6.2.

Administration costs included the salaries and administrative expenditures by head office, district office and sub-district office staff attributable to the plantation operations and other indirect expenditures of pay roll tax, worker compensation, stationery, rents,etc.

Administration costs were very difficult to estimate accurately because records of the actual working hours covering the management of the plantation was not available from either the head office ,district office or the sub-district office. However the Department did indicate that administration costs are largely independent of the methods used for plantation establishment and together amount only one fifth of the total direct field expenditure (Queensland Department of Forestry, 1974 pers.comm.). Consequently for this study administration costs were assumed to be 20 per cent of the direct field expenditure .

TABLE 6.2

TOTAL INDIRECT LABOUR REQUIREMENT AT LOCAL OFFICE
IN THE BOWENIA PLANTATION BASED ON A PLANTING RATES
OF 200 HECTARES PER YEAR
(base-year = 1974)

ITEMS/YEAR :	1-3		4-16		16-20		20-40	
-	Number	wages	Number	wages	Number	wages	Number	wages
Mechanic	1	6200	1	6200	1	6200	1	6200
Storeman	1	6200	1	4500	1	4500	1	4500
Drivers	1	5200	2	10400	2	10400	2	10400
Carpenter	1	4500	1	4500	1	4500	1	4500
Clerk	1	4500	1	4500	1	4500	2	9000
Typist	0	0	0	0	1	5400	1	5400

6.2 Revenues

Annual revenues for the analysis from the Queensland Department of Forestry viewpoint were obtained by multiplying the value received by the Queensland Department of Forestry in 1974 for sawlogs at stump given in Tables 5.2 and 5.3 by the estimated sawlog yield given in Table 3.2 and 3.3 . The cash flow of revenues from the project over the first rotation are summarised in Table 6.3 . Actual 1974 costs of felling, extraction and transportations from the Bowenia plantation to the Rockhampton market were used throughout .

6.3 Costs and revenues for subsequent rotations.

The plantation revenues for the second and subsequent rotations were assumed to remain constant at the year 1974 level (the sustained yield level reached after the end of the first rotation). Clearing and sites preparation and cultivation costs in the second and subsequent rotations were assumed to be half of those occuring in the first rotation. Survey costs were assumed to be negligeable and roads and firebreaks would only require maintenance expenditure in the second and subsequent rotations. The annual maintenance costs were assumed to be $10.00 per hectare per year.

These costs and revenues were then used to calculated the NDR of the plantation development from the Queensland Department of Forestry viewpoint .

CHAPTER 7

RESULTS OF THE ANALYSIS FROM THE QUEENSLAND DEPARTMENT OF FORESTRY VIEWPOINT

Estimates of the NDR for the Bowenia plantation development from the Queensland Department of Forestry viewpoint were obtained for a variety of sawlog prices and sawlog yields assumptions.

Two different thinning regimes which were designed to produced high quality sawlogs from the final crop trees of *Pinus caribaea* were made available by the Queensland Department of Forestry for the study. However, the yield information was of necessity not specific to the plantation and on the basis of more recent information appears to underestimate actual sawlog yields. The higher yields could not however be incorporated into the analysis which was based on the derived stumpage prices of sawlogs and the cost of development outlined in Chapter 6.

The total costs of developing the plantation during the first rotation fluctuated between $134,206 and $365,324 per annum reaching a maximum in year 25. Table 6.3 shows the cost of developing the Bowenia plantation up to the point where, at the end of forty years, capital expenditure is complete and the 8000 hectares forest of *Pinus caribaea* can operate with a stable physical output and stable costs. The appendix 6.3 and Table 6.3 were used to estimated the annual total costs which relate to the normal forest operating at a stabilised level of output from year 41. The estimated annual cost for year 41 was $240,740.

The revenues from the project, under regime R1 commenced in year 16 (1990) and rose steadily to $1,727,071 per annum by year 40 (2014). The estimated annual revenue for regime R1 in year 41 (and onwards) was $1,727,071 .

Under regime R2, revenues commenced in year 13 (1987) and rose to $1,401,208 by year 2014.

The future net worth of the plantation was obtained by deducting the compounded net cost of development from the capitalised value of the sustained yield annual net revenue which from year 41 is assumed to continue at that level in perpetuity. The capitalised value of the sustained yield annual net revenue of the plantation in year 41 was $29,726,620 or $3715 per hectare while the compounded net cost of development amounted to $19,363,800 or $2420 per hectare. Deducting the future cost from the future revenue gives the future net revenue of $10,362,900; and by discounting this value over forty years at 5 per cent gives a NDR in year 1 of $1,472,000 . This figure gives the future values of the Bowenia plantation as a fully stocked of forest products. The net financial costs and returns of the project during the first rotation under regime R1 are given in Table 6.3 .

The Net Discounted Revenue of the project was calculated by discounting the future net worth over 40 years back to the base year (1974).

Initially constant stumpage prices PL1 and costs TL1 1974 base year were used to calculate the NDR of the project using a discount rate of 5 per cent. In addition the sensitivity of the NDR to changes in prices,costs and interest rates was also examined and is discussed in section 7.2.

7.1 Net Discounted Revenues (NDR).

The NDR of the project under regime R1 (thinned at age 7 to a stocking of 740 stems per hectare with four subsequent thinnings) was $184 per hectare whereas for the lighter thinned regime R2 thinned at age 7 to a stocking of 988 stems per hectare with five subsequent thinnings) it fell to $80 per hectare. These results indicate that the project is economically desirable managed under either regime R1 or R2 at the discount rate of 5 per cent assuming that a positive NDR is the appropriate criterion of economic viability. Table 7.1 and Figure 7.1 give the NDR of the project under both regimes over a range of discount rates between 3 and 8 per cent .

TABLE 7.1

NET DISCOUNTED REVENUE PER HECTARE FOR THE BOWENIA PLANTATION UNDER REGIME R1 AND R2

($/ha)

	REGIME	
Interest rate	R1	R2
3%	1477	1086
4%	587	393
5%	184	80
6%	-12	-69
7%	-108	-140
8%	-154	-174

7.2 Sensitivity Analysis

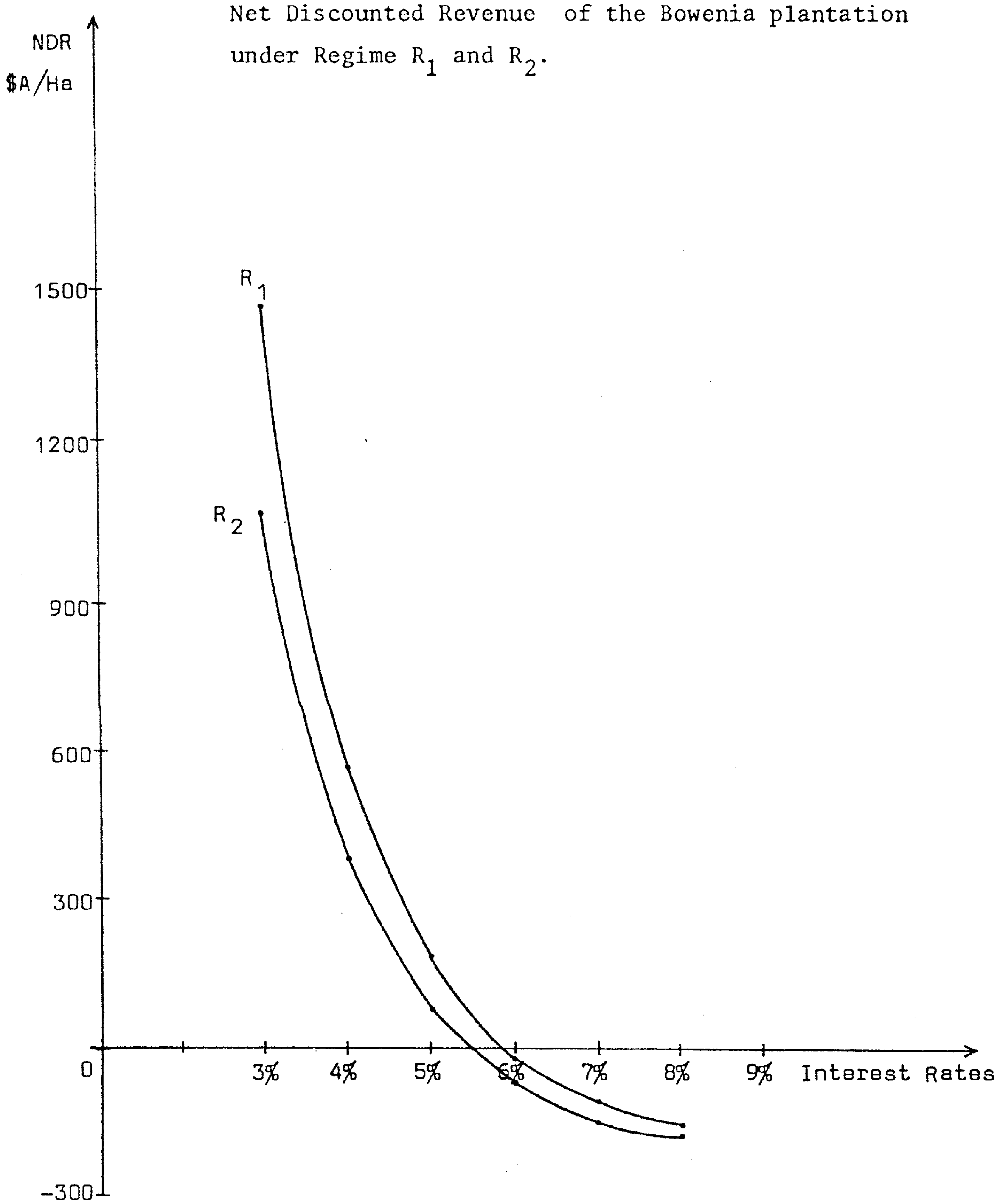
A sensitivity analysis was carried out to examine the effects of variations in the costs and revenues of the project on the NDR .

Five sawntimber prices and cost assumptions were examined. They are as follows :-

1 - Stumpage prices increasing by 0.5 per cent per annum (PL2) over the development phase then remaining stable from year 2014 onwards (PL2). This price level assumption was based on actual increases in the real price of sawntimber observed during a study of land use on the South Coast of New South Wales (Reilly,1976 pers.comm.).

Figure 7.1

Net Discounted Revenue of the Bowenia plantation under Regime R_1 and R_2.



2 - Stumpage prices increasing by 1.00 per cent per annum up to year 2014 (PL3) in line with real long term rate of increase in the wholesale price of imported sawn Douglas fir from the United States .

3 - Stumpage prices increasing by 1.5 per cent per annum (PL4) based on the rate of real price increase for Douglas fir stumpages in the United States between 1955/56 and 1973/74, this being the most optimistic level of price increases examined.

4 - Stumpage prices increasing by 30 per cent above the 1974 level and remaining at that level for all subsequent rotations(PL5);

5 - Labor costs increasing in real terms by 1 per cent per annum (TL2) between 1974 and 2014 then remaining stable .

7.2.1 Prices of sawlogs

A constant discount rate of 5 per cent was used to examine the influence of stumpage prices on the project's profitability. For regime R1 the NDR rose progressively as price level assumption were changed from PL1 to PL2, Pl5, PL3 with PL4 giving the highest NDR per hectare. Details are given in Table 7.2 and figure 7.2. The NDR of regime R1 was greater than that for regime R2 for all price levels examined with the margin increasing with price level. The NDR for regime R1 under price level PL2 was $339 per hectare while the corresponding figure for regime R2 was $213 per hectare.

The NDR per hectare under price assumption PL3 was $ 527 for regime R1, some $226 per hectare below the NDR for stumpage price assumption PL4 but still $343 per hectare above the NDR for price assumption PL1. Similarly the NDR for regime R2 under price assumption PL3 was $370 per hectare, some $290 per hectare above the NDR under the PL1 price assumption but some $194 per hectare less than NDR for the regime R1 under PL3 . The NDR under the different stumpage prices and costs for regime R2 are given in Table 7.3 and Figure 7.3.

The NDR per hectare for regime R1 under price assumption PL4 , a 1.5 per cent per annum rise in price rose to $753 per hectare while the corresponding figure for regime R2 was $564 per hectare. Both were calculated using a discount rate of 5 per cent.

Under price level PL5, the NDR for regime R1 was $405 per hectare, an increase of $221 per hectare above the PL1 constant price level NDR at the same rate of discount. For regime R2 the NDR per hectare rose to $271 per hectare, an increase of $189 per hectare above the base level constant price NDR for the same rate of discount.

TABLE 7.2
NET DISCOUNTED REVENUE OF THE BOWENIA PLANTATION
UNDER REGIME R1 AT DIFFERENT STUMPAGE VALUES LEVELS
($/per hectare)

NDR($/ha)	PL1	PL2	PL3	PL4	PL5
3%	1477	2000	2633	3398	2204
4%	587	862	1195	1596	974
5%	184	339	527	753	405
6%	-11	81	192	326	122
7%	-108	-51	17	99	-24
8%	-154	-118	-75	-24	-100

TABLE 7.3
NET DISCOUNTED REVENUE OF THE BOWENIA PLANTATION
UNDER REGIME R2 AT DIFFERENT STUMPAGE VALUES LEVELS
($/per hectare)

NDR($/ha)	PL1	PL2	PL3	PL4	PL5
3%	1086	1522	2044	2688	1698
4%	393	624	901	1242	722
5%	80	213	370	564	271
6%	-69	10	105	221	48
7%	-140	-91	-33	39	-67
8%	-174	-142	-105	-58	-126

Figure 7.2

Net Discounted Revenue of the Bowenia plantation under Regime R_1 at different stumpage value levels.

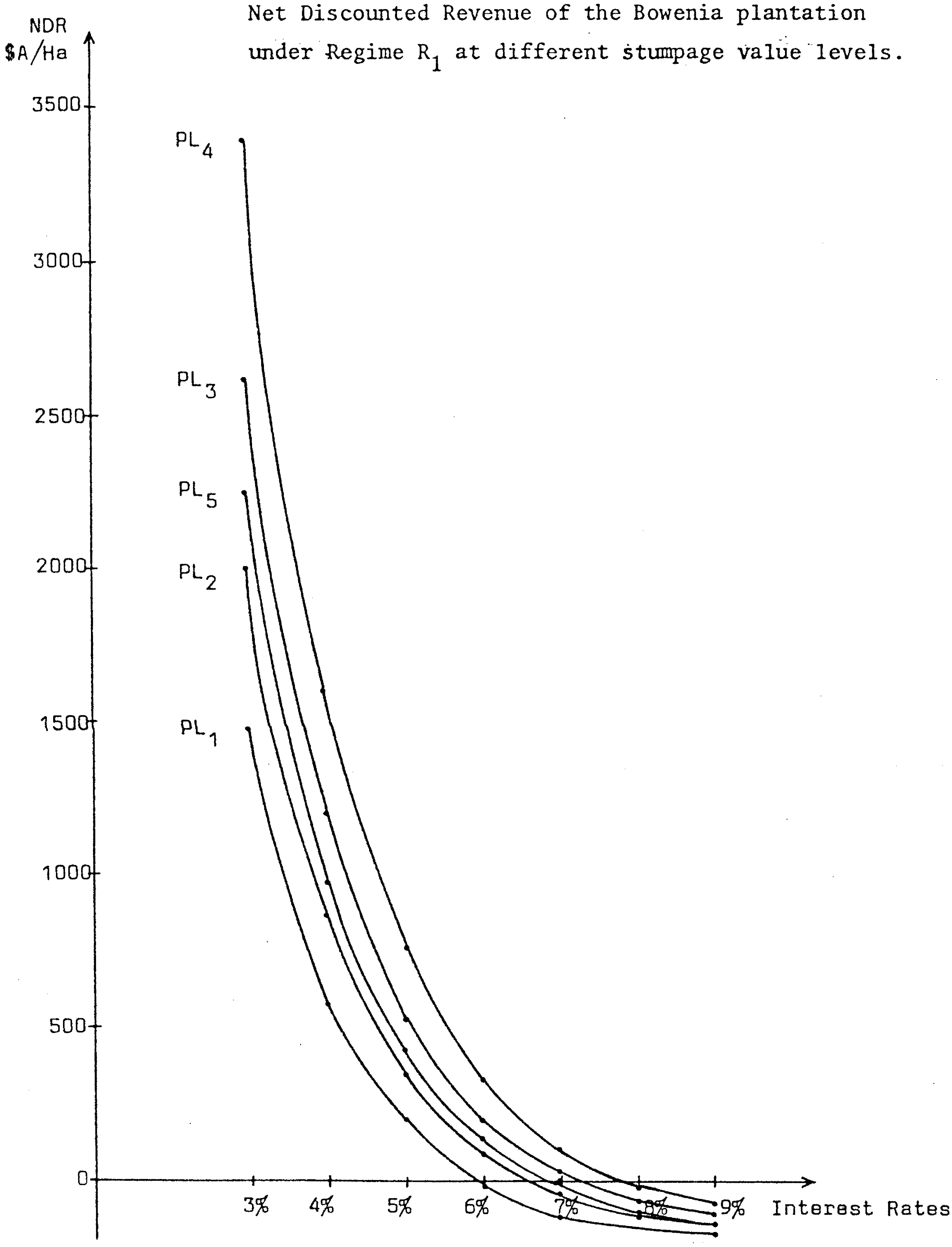
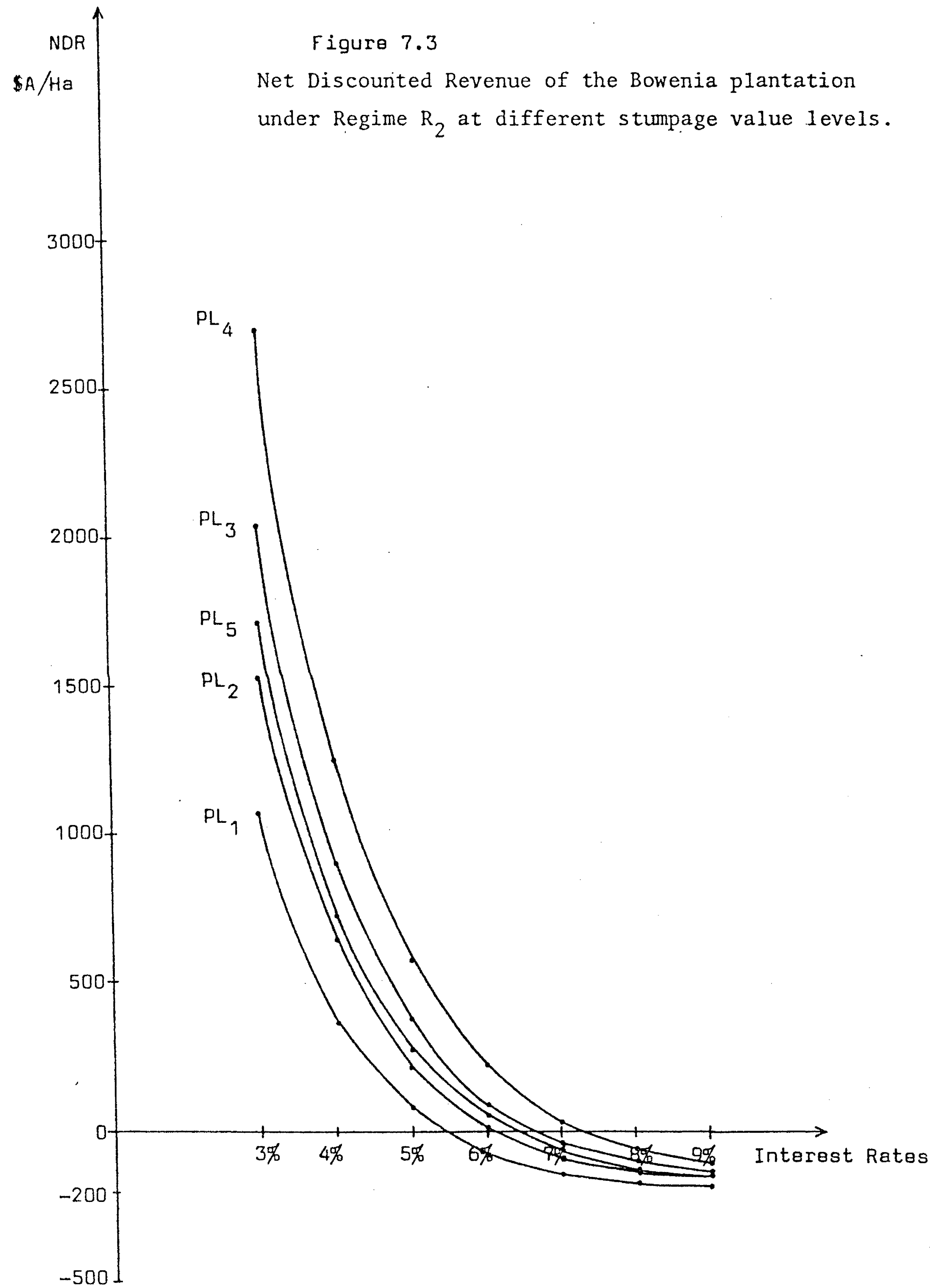


Figure 7.3
Net Discounted Revenue of the Bowenia plantation under Regime R_2 at different stumpage value levels.



7.2.2 Costs

As most of the forestry operations in the Bowenia forestry plantation were generally labour intensive, an examination of increases in real wage costs was thought desirable. Therefore the effect of an increase in the real cost of labour by 1 per cent per annum (TL2) eas examined for regime R1 and R2 firstly under price level PL1. The result was a decrease in the NDR per hectare by $134 for regime R1 and $133 for regime R2 using a 5 per cent discount rate.

7.2.3 Combined-effect of prices ,costs and rate of discount

The plantation project managed under regime R1 remained economically viable at a discount rate of 5 per cent under all price and cost assumptions. Regime R1 was still economically viable at a discount rate of 6 per cent provided stumpage prices rose by Ø.5 per cent per annum (PL2) under cost level TL1 and by 1.Ø per cent per annum (PL3) under cost level TL2. At a 7 per cent discount rate only price level PL4 (a 1.5 per cent per annum rate of price increase) gave a positive NDR under cost level TL2 whereas under cost level TL1 both PL3 and PL4 gave positive NDR's. Details of the NDR's per hectare for regime R1 under the range of stumpage values and costs examined are given in Table 7.4 and Figure 7.4 and for regime R2 in Table 7.5 and Figure 7.5

TABLE 7.4
NET DISCOUNTED REVENUE OF THE BOWENIA PLANTATION
UNDER REGIME R1 AT DIFFERENT STUMPAGE VALUES LEVELS AND COSTS
($/per hectare)

NDR($/ha)	PL1	PL2	PL3	PL4	PL5
-	TL2	TL2	TL2	TL2	TL2
3%	1176	1704	2332	3097	1902
4%	394	674	1000	1403	780
5%	50	210	398	619	271
6%	-108	-13	94	228	24
7%	-182	-122	-56	25	-98
8%	-212	-174	-132	-81	-158

TABLE 7.5
NET DISCOUNTED REVENUE OF THE BOWENIA PLANTATION
UNDER REGIME R2 AT DIFFERENT STUMPAGE VALUES LEVELS AND COSTS
($/per hectare)

NDR(/ha)	PL1	PL2	PL3	PL4	PL5
-	TL2	TL2	TL2	TL2	TL2
3%	785	1221	1747	2387	1397
4%	200	431	710	1049	528
5%	-53	79	238	430	137
6%	-166	-87	8	128	-50
7%	-214	-165	-106	35	-141
8%	-231	-199	-162	-116	-183

Figure 7.4

Net Discounted REvenue of the Bowenia plantation under R_1 at different stumpage value levels and costs.

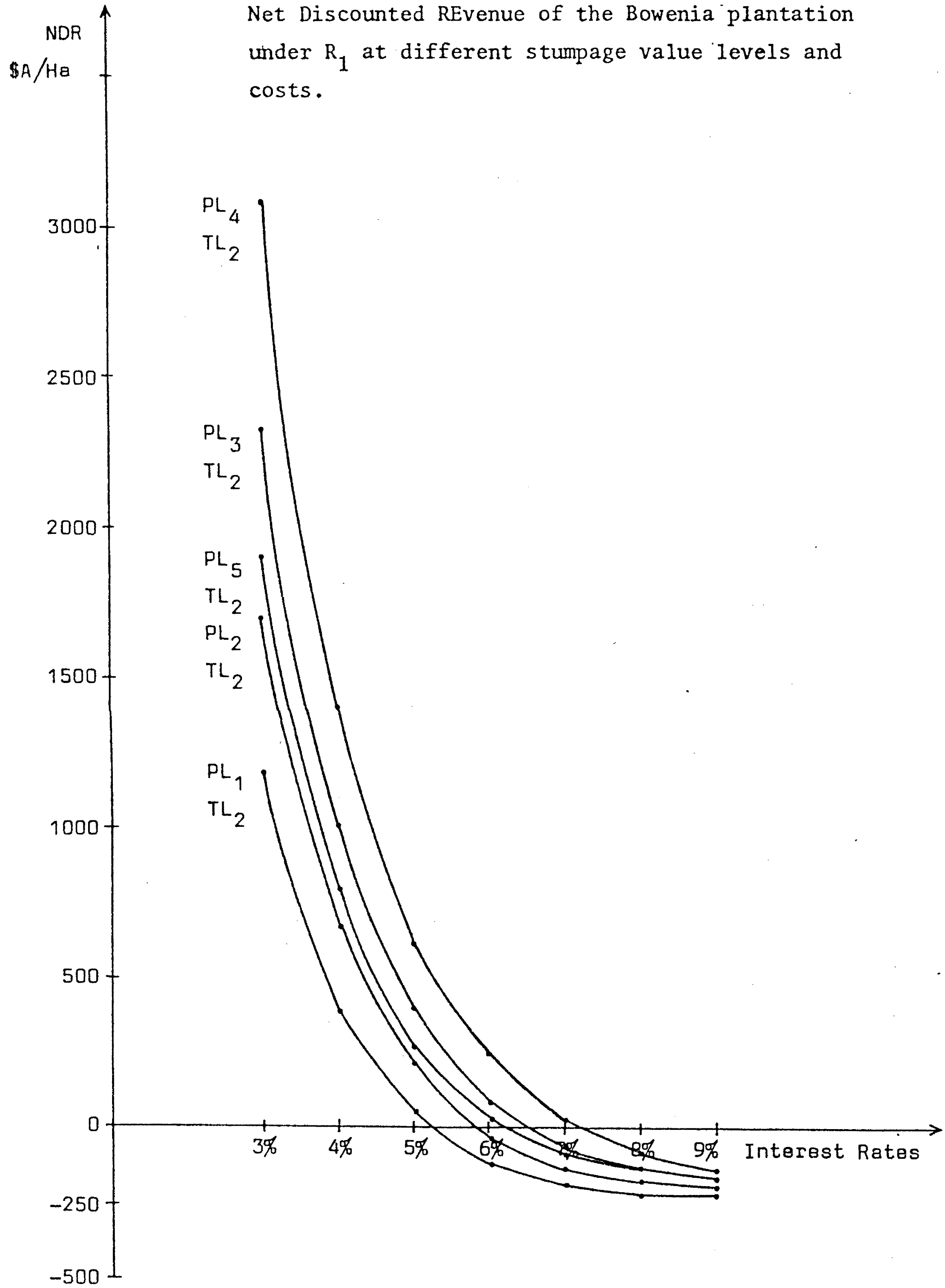
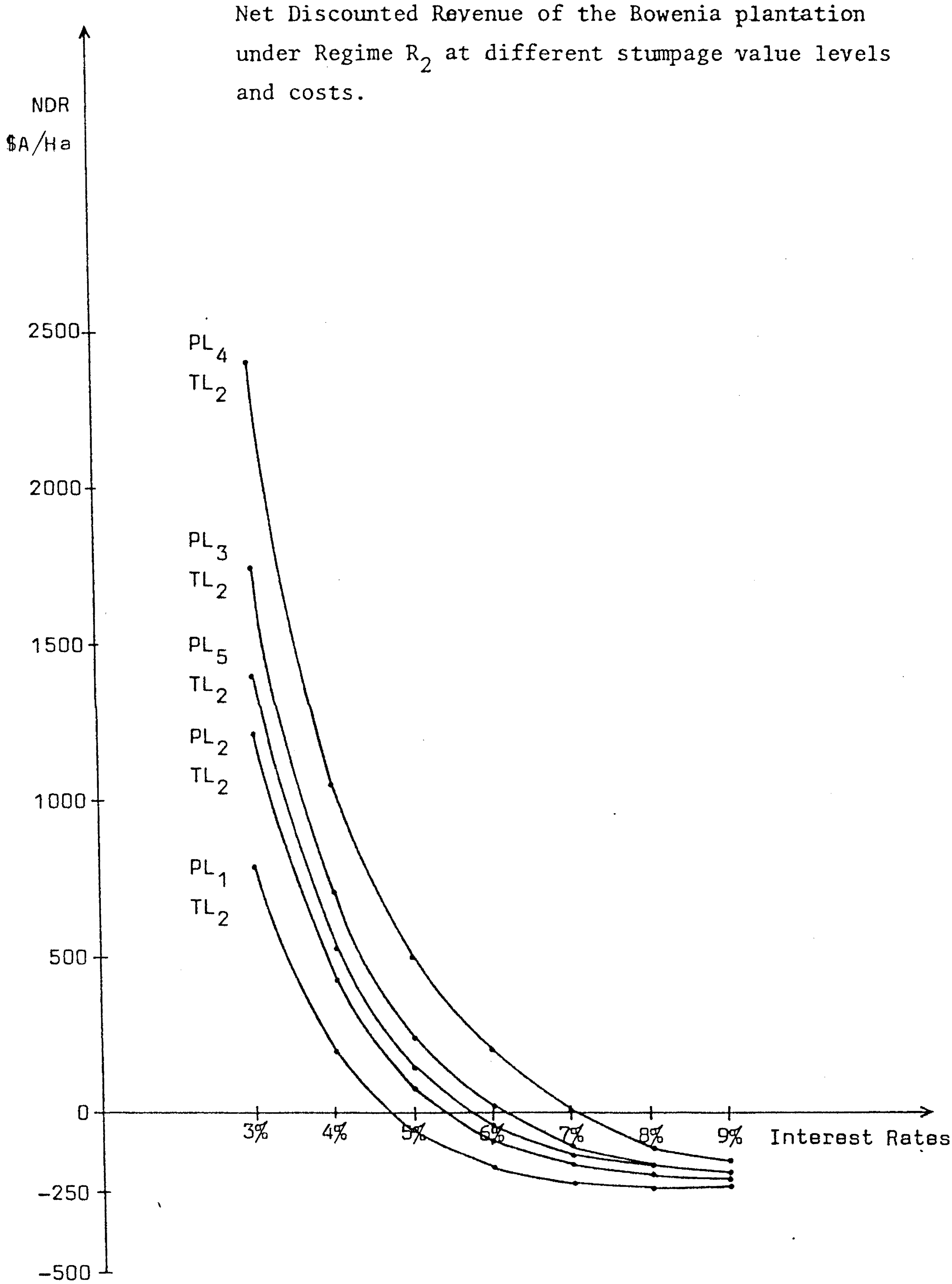


Figure 7.5

Net Discounted Revenue of the Bowenia plantation under Regime R_2 at different stumpage value levels and costs.



The NDR per hectare (at a 5 per cent discount rate) for regime R2 under price level PL1 and cost level TL2 was -$53, some $103 per hectare less than the NDR per hectare for regime R1 at the same price and cost level . The NDR per hectare was positive (at 5 per cent discount rate) for all other price levels at cost level TL2.

The NDR obtained from both regime R1 and R2 illustrates that the discount rate has a marked effect on the profitability of the project. Forestry development projects because of their long term nature tend to be very sensitive to changes in the discount rate. The NDR was reduced by some $1126 per hectare when the interest rate was increased from 3 per cent to 5 per cent it dropped by only $262 per hectare when the interest rate was increased from 5 per cent to 8 per cent.

The NDR per hectare has a net increase of $214 when stumpage prices and development costs were increased by one per cent per annum.

The NDR was more sensitive to the stumpage prices than the costs of development and the discount rate.

CHAPTER 8

NET SOCIAL BENEFIT OF THE BOWENIA PLANTATION

8.1 Introduction

In this chapter and in chapter 9, the economic benefit of the Bowenia plantation project are examined from the national viewpoint. The Net Social Benefit of the project(NSB) was evaluated in social terms but , in this respect, a major limitation of this study was that the benefits and costs were confined solely to wood production. The level of wood production from the plantation was expected to maintain the supply/demand balance over time within the region and was not likely to cause a significant change in local market prices. Ferguson (1973a) indicated that the consumer's surplus under these conditions was not likely to alter appreciably and the analysis of social benefit simplified to an evaluation of the social revenues and costs directly attributable to wood production.

8.2 Revenue

Social revenues received from the Bowenia plantation were estimated using the shadow stumpage values of sawlogs derived in Chapter 5. The sawlog output from the plantation would inevitably have a considerable variability in grade irrespective of how the plantations were managed . Consequently an assessment of the value of sawntimber produced from the plantation provided a number of difficulties. One of the basic assumptions required for this assessment was that the sawntimber produced from the plantation would substitute for and directly compete with imported sawntimber. The most optimistic assumption was that *Pinus caribaea* sawntimber would substitute for sawn *Douglas fir* which could be landed at Gladstone for $122.35 per cubic metre in 1973/74 prices. To test the sensitivity of the results to changes in the price of output, a sensitivity analysis was carried out which used the price of imported sawn *Pinus radiata* from New Zealand landed at Gladstone of $94.16 per cubic metre and the domestic prices of indigenous sawntimber in the Rockhampton region market of approximately $67.0 per cubic metre.

All shadow stumpage values for *Pinus caribaea* based on the shadow price of sawn *Douglas fir* imported from the United states ,*Pinus radiata* imported from New Zealand and indigenous sawntimber in the Rockhampton region increasing by one per cent per annum in real terms up the year 2014 (over the first rotation) were also examined.

Revenues from the plantation were obtained by multiplying the sawlog yield summarised in Table 3.2 and 3.3 by the stumpage prices given in Tables 5.8 .The resulting total annual revenues are presented in Table 8.1.

8.3 Costs

Four main components of costs were used in estimating the total expenditure of the Bowenia forestry plantation development programme : Field expenditure, administration costs , equipment costs and annual running costs. The costs in the financial analysis were used as the basis for calculating social costs. The direct field expenditures associated with the project depended upon the wage rates paid to the labourers working in the plantation. The indirect labour and administrative costs attributable to the project in turn depended upon the salaries paid to the supervisory staff from head office and sub-district office.

The wages and salaries paid to forestry labourers and professional foresters should, in theory, represent their value of productivity. In practice, it is extremely difficult to estimate the difference, if any, between the wages and salaries paid to employees and the true social value of labour within the project.

Revenues were obtained by using the shadow prices of sawlogs,so, the total expenditures must also be expressed in terms of their social values. Although shadow wage rates are difficult to estimate, they are very important in this forestry project because most of the operations under the current management practices are relatively labour intensive. Because of this the Bowenia project is likely to be sensitive to changes in the shadow prices applied .

The work force which is available from within the region and is currently employed in the Bowenia plantation was estimated to average between 30 and 40 men per year. The shift of employment opportunity from agriculture is unlikely to influence the level of production in that sector because the establishment and silvicultural operations are generally seasonal. It was also assumed that the level of wages was unlikeky to change as a result of the employment opportunities created within the Bowenia plantation. In Australia, the wages paid to forestry workers are set by the Industrial Concilliation and Arbitration Commission and remain fixed regardless of the employement situation in the economy or the region . The average award weekly wage rate for general forestry workers in 1974 was $92.00. The use of this wage rate for calculating the total wage costs seems reasonable particularly when it is recognised that the Australian economy until recently was managed on a full or close to full employment basis.

Recent economic conditions and economic management have confused the likely long term employment situation but the subsequent analysis was based on a return to a full employment situation in the near future . Under full employment conditions the shadow price of wages and salaries were assumed to be the same as the financial wages and salaries with the result that the total labour costs of the development being the same as in the analysis from the Queensland Department of Forestry viewpoint. If the present high level of unemployment in both the Rockhampton and in the country as a whole become the norm then the social opportunity costs of labour wage will have been considerably overestimated. Equipment costs were assumed to be the same as those used in the previous analysis .

8.3.1 Source of capital

The Bowenia plantation development programme was carried out by the Queensland Department of Forestry as part of its planned expansion of softwood plantations. The cost of development was financed partly from loan funds under the Australian Softwood Forestry Agreement Act , partly from its own state loan funds and the remainder from consolidated revenues. Although detailed information was not available it appeared that direct labour and equipment costs were financed from loan funds. These costs represented approximately 80 per cent of the total annual expenditure on the project. Administrative costs and overheads were financed from consolidated revenues. In the sensitivity analysis the effect of a lower proportion of 60 per cent of direct labour and equipment costs being financed from loan funds was also examined.

Plantation forestry in Queensland has generally been restricted to areas where land was already available to the Department of Forestry. These areas were usually on soils which were marginal for agriculture and which did not offer sufficiently high returns for them to attract private investors. Consequently the funds used for plantation forestry development would most likely have yielded higher rates of return or a greater net social benefit if left in private investments. The opportunity cost of diverting funds from private investment to public investment in order to finance public programmes is called the social opportunity of capital. Feldstein (1964c) argued that when a social cost-benefit analysis was being undertaken the social opportunity cost of capital transferred from private sources to finance the particular public programme should be taken into account when the social rate of time preference was used to discount the costs and benefits of the programme.

8.2.2 The social opportunity cost of capital

Feldstein (1964c) defined the social opportunity cost of capital funds transferred from the private sector to the public sector as the discounted value of the consumption stream that is foregone as a result of the transfer (the appropriate rate of discount being the social rate of time preference). Ferguson (1973a) referred to the social opportunity cost of capital as a shadow price on funds diverted from private investment. Ferguson and Reilly (1975) modified the formula for the shadow price of capital derived from loan funds developed by Dasgupta, Sen and Marglin (1972) . The modified formula for the shadow price of capital is given in equation 8.1 .

$$L_s = \frac{r_p\left[1-m_p(1-t)\right]}{i_g-r_p m_p(1-t)} \qquad (8.1)$$

where t = denotes the marginal tax rate on corporate income;

mp= denotes the marginal propensity to save;

rp= denotes the marginal rate of return before ta private investment ;

ig= denotes the social rate of time preference.

The shadow prices of loan funds, using the formula (8.1) was estimated to be 2.73 when a social rate of time preference (SRTP) of 5 per cent was used and 2.19 when the SRTP was assumed to be 6 per cent (Ferguson _et al._,1975). The expenditures on overhead and supervisory staff which were assumed to be financed from Consolidated revenues have a shadow price of unity. The above shadow prices for loan funds were used to derive the social costs of the project . The total annual social costs for wood production are given in Table 8.1 .

TABLE 8.1
SOCIAL COSTS AND REVENUES OF THE BOWENIA PLANTATION UNDER REGIME R1 AND R2.

Year	Social costs based on 80% of total expenditure financed from loans funds		Revenues based on shadow prices of imported sawn Douglas fir	
	shadow price of capital 2.73	shadow price of capital 2.19	R1	R2
-			-	-
-			-	-
1974	632871	518189		
1975	319947	261970		
1976	334409	273811		
1977	418968	343048		
1978	373914	306158		
1979	393749	322656		
1980	394063	322656		
1981	432513	354138		
1982	667723	546726		
1983	480853	393718		
1984	577709	473024		
1985	573905	469908		
1986	518515	424556	-	3459
1987	573324	469433	-	3459
1988	635398	520259	-	3459
1989	561470	459727	98486	3459
1990	724297	593049	98486	3459
1991	542183	443935	98486	268153
1992	538345	440793	98486	268153
1993	653015	534684	98486	268153
1994	612926	501695	364339	268153
1995	549073	449577	364339	268153
1996	613441	502281	364339	613356
1997	599399	490783	364339	613356
1998	870933	713113	364339	613356
1999	579608	474578	364339	613356
2000	560321	458787	886384	613356
2001	620851	508348	886384	1033557
2002	556483	455644	886384	1033557
2003	648291	530815	886384	1033557
2004	699279	572568	886384	1033557
2005	556483	455694	886384	1033557
2006	746273	611043	1216057	1442970
2007	602971	493708	1216057	1442970
2008	684981	560857	1216057	1442970
2009	643976	527282	1216057	1442970
2010	556483	455644	1216057	1442970
2011	556483	455644	1216057	1442970
2012	624687	511490	1216057	1442970
2013	644453	527673	4622618	4130100

CHAPTER 9

RESULTS OF THE SOCIAL COST-BENEFIT ANALYSIS

In this chapter, the discounted net social benefit (NSB) was used to measure the worthwhileness of the Bowenia plantation from the national viewpoint. Benefits generated from the plantation development are numerous including such things as wood production, watershed, erosion protection, recreation. However, in this study, the NSB calculations were restricted to wood production based on the constraints mentioned in chapter 4.

A sensitivity analysis was also carried out over a range of residual shadow prices (based on imported sawntimber prices) and plantation development costs.

9.1 Basic analysis

9.1.1 The social costs of development

The annual cost to society to develop the plantation rose from $319,947 in 1975 to $573,905 in 1995. From 1995 until the end of the development stage in 2014 the annual total costs fluctuated between $573,905 and $644,453. The shadow price of loan funds made up a substantial proportion of those costs. The annual costs of forest operations for the second and subsequent rotations were constant at $240,740 per annum and were assumed to be financed from the project's revenues which have a shadow price of capital of unity.

9.1.2 The social revenues from development

The social revenues for the basic analysis were derived by multiplying the annual yields generated by the development with the residual shadow prices based on imported sawntimber Douglas fir landed on the Rockhampton market (price assumption A). The annual revenue stream followed a similar trend over time to the revenue stream obtained in the earlier analysis outlined in chapter 6. Under regime R1, the first revenue of $98,486 was generated in year 1990. After 1990 revenues rose steadily levelling out at $4,622,618 per annum after year 40 (2014). Under regime R2, the first revenue of $3,459 was received in year 1987, but rose to $4,143,260 by year 2014 and stabilised at this level from then onwards.

9.1.3 Future net worth of the Bowenia plantation

The compounded net cost of development for regime R1 under price assumption A (residual shadow price based on imported price of sawn Douglas fir) at the end of year 40 was $37,287,560 or $4660 per hectare when using a 5 per cent social rate of time preference. The uniform annual net forest revenue from year 41 onwards was capitalised using a 5 per cent SRTP to give the value as a going concern of the sustained yield forest which at the beginning of year 41 amounted to $87,637,560 or $10,954 per hectare. Deducting the future cost from the future revenue gives the future net social revenue of the 8000 hectare plantation development of 50,350,000 or $6300 per hectare.

The NSB of the Bowenia plantation was calculated by discounting all social costs and social revenues using equation (4.6) to the base year 1974. A discount rate based on the social rate of time preference of 5 per cent was used initially but this was later raised to 6 per cent to test the sensitivity of the NSB of the project to change in the rate of time preference. (including a recalculation of the shadow price of loan funds).

9.1.4 Net Social Benefit

The NSB of developing the Bowenia plantation under a range of price assumptions is presented in Table 9.1 .

The NSB of regime R1 was $7,152,000 or $895 per hectare under price assumption A (shadow prices of imported sawn Douglas fir at Rockhampton), 80 per cent of the total expenditure financed from loan funds and using the social rate of time preference of 5 per cent. Under regime R2 the Net Social Benefit of the project at 5 per cent was $6,580,000 , or $822 per hectare. This was $672,000 (or $84 per hectare) lower than the Net Social Benefit under regime R1. These represent an increase of $722 per hectare above the NDR per hectare of regime R1 and R2 obtained in the analysis from the Queensland Forestry Department viewpoint at the same discount rate .

The Net Social Benefit for the project under regime R1 and R2 was $446 and $415 per hectare respectively when a social discount rate of 6 per cent was used. This is nearly 50 per cent lower than the NSB obtained at 5 per cent but is approximately 105 per cent higher than the NDR per hectare obtained in the analysis from the Queensland Forestry Department viewpoint. It might be expected that the drop in NSB of the project resulting from an increase in the discount rate from 5 to 6 per cent under either regime would mirror the decrease of the NDR seen in the previous analysis. However, this did not follow because changes in the social rate of time preference also changed the social opportunity cost of capital.

9.2 Sensitivity analysis

A sensitivity analysis was carried out to examine the effect of variations in the social costs and social revenues of the plantation on its NSB. As the resuls of the earlier sensitivity analysis in chapter 7 showed that the NDR was very sensitive to price changes . Therefore , three levels of shadow stumpage prices based on substitutes that *Pinus caribaea* will have to compete with in the Rockhampton market were examined and the results are given in Table 9.1. The prices and costs alternatives examined were:-

1- Shadow stumpage prices of *Pinus caribaea* based on the fob import price of sawn *Pinus radiata* from New Zealand (price assumption B).

2- Shadow stumpage prices for *Pinus caribaea* based on the price of indigenous sawntimber in the Rockhampton market (price assumption C).

3- An increase in the three alternative shadow stumpage prices of 1 per cent per annum (assumptions A1,B1 and C1 respectively).

TABLE 9.1
NET SOCIAL BENEFIT OF THE BOWENIA PLANTATION

Price assumptions and Management objectives	Net Social Benefit at Rockhampton 60% of total Expenditure Financed from Loan funds		80% of total Expenditure Financed from Loan funds	
-	5%	6%	5%	6%
A- Sawlog stumpages value based on imported Douglas fir sawn timber shadow prices.				
1- Regime R1				
a) As under price assumption A	$1043	$ 526	$ 895	$ 446
b) As under price assumption A1	$2005	$1103	$1913	$1023
2- Regime R2				
a) As under price assumption A	$ 959	$ 495	$ 822	$ 415
b) As under price assumption A1	$1850	$1035	$1714	$ 954
B- Sawlog stumpage value based on imported Pinus radiata sawn timber shadow prices.				
1- Regime R1				
a) As under price assumption B	$289	$63	$152	$-17
b) As under price assumption B1	$958	$434	$773	$354
2- Regime R2				
a) As under price assumption B	$244	$50	$108	$-29
b) As under price assumption B1	$821	$399	$685	$319
C- Sawlog stumpage values based on Indigen ous softwood shadow prices				
1- Regime R1				
a) As under price assumption C	$167	$-11	$31	$-92
b) As under price assumption C1	$771	$326	$630	$246
2- Regime R2				
a) As under price assumption C	$129	$-40	$-7	$-101
b) As under price assumption C1	$656	$298	$520	$217

4- A decrease in the percentage of total expenditure financed from loans funds from 80 to 60 per cent.

9.2.1 Price of sawlogs.

The NSB of regime R1 under price assumption B (residual shadow price based on imported sawn Pinus radiata at Rockhampton) were $152 per hectare, some $754 per hectare below the NSB under price assumption A. Similarly, the NSB for regime R2 was $108 , some $714 below the NSB under price assumption A. Both were evaluated at 5 per cent S.R.T.P.

Under price assumption C (residual shadow price based on indigenous softwood price in Rockhampton), the NSB per hectare for regime R1 was $31 when discounting at 5 per cent SRTP, some $875 per hectare below the NSB for the same regime but under price assumption A. Under the same price assumption C , the NSB for regime R2 was negative being -$7 per hectare ,some $38 below the NSB for regime R1.

The NSB per hectare for either regime R1 and R2 was extremely sensitive to price changes.

A rise in the real price of imported sawn Douglas fir by one per cent per annum lifts the NDR at 5 per cent to $1913 per hectare for regime R1 and to $1714 per hectare for regime R2. If the same increase occur in the real price of imported sawn Pinus radiata, the NSB at 5 per cent for regime R1 rises to $773 per hectare and for regime R2 to $685 per hectare .

9.2.2 Social rate of time preference.

As mentioned earlier the NDR is very sensitive to change in the discount rate when the project is developed over a long time period. In this particular analysis, the Net Social Benefit of both regimes under all assumptions A, B, and C decreased but at a slower rate than the NDR's decreased in chapter 7 . This was largely due to the social opportunity cost of capital changing with the rate of time preference.

9.2.3 Loan funds

The Net Social Benefit of the project was recalculated using the range of stumpage values of sawlogs outlined earlier but with only 60 per cent of total expenditure financed from loan funds. Under this assumption, the Net Social Benefit at 5 per cent for both regime R1 and R2 increased by between \$60 and \$100 per hectare depending on the rate of discount and price level. The Bowenia plantation at Byfield has a negative Net Social Benefit, if the sawlog output has to compete with either indigenous species or imported Pinus radiata at the Rockhampton market under price assumptions B and C when the social rate of time preference was increased to six per cent.

At the national level, the Net Social Benefit of the plantation established solely to supply sawlogs to the local market, is more economical if the expected stumpage values are equal to the shadow prices based on the price of imported sawn Douglas fir. When the plantation approaches the sustained yield stage, and if the expected price of either imported sawn Pinus radiata or indigenous species increase by 1 per cent per annum, the project becomes a sound financial investment, provided sawn *Pinus caribaea* successfully substitutes for imported sawn *Pinus radiata* and locally produced indigenous sawntimber .

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

In this study the technique of cost-benefit analysis was used to appraise the economic worthwhileness of the Bowenia plantation development programme. Some modifications were necessary because the inclusion of particular costs and benefits depended on the viewpoint from which the study was being examined. At the national level, costs and benefits should have included all tangible, intangible and external costs and benefits. However, because of the limitation of data and time the scope of this study was restricted to the measurement of the direct and indirect costs and the benefits associated with sawlog production which were readily measurable in monetary terms.

This chapter summarises the assumptions and major conclusions which may be drawn from both the analysis from the Queensland Department of Forestry and from the national viewpoint.

10.1 Assumptions

A study of this nature requires a large amount of physical and financial data much of which was not available to the writer. Consequently a number of assumptions had to be made during the study.

Most of the assumptions which were made, either implicitly or explicitly have already been discussed in chapter 4 but the most important of these are summarised below :-

1- Areas

An annual planting rate of 200 hectares was adopted from 1974 onwards.

2- Species

Pinus caribaea was assumed to be the only species planted. In practice, the historical planting rate from 1949 to 1974 was very uneven and several species were planted, the two main species being slash pine (*Pinus elliottii*) and *Pinus caribaea*.

3- Planning horizon

The total area of the reserve was assumed to be set aside solely for forestry plantation. The planning period used was the same as the rotation length which for sawlog production was assumed to be 40 years. It was also assumed that the plantation would attain the sustained yield state by the end of the first rotation.

4- Silvicultural regime and Site index

Two different thinning regimes were analysed:-

a) a reduction of stocking to 740 stems per hectare between years 5 and 7, with four subsequent thinnings carried out at age 16,21,27 and 33 years (Regime R1).

b) a reduction of stocking to 988 stems per hectare between years 5 and 7, with five subsequent thinnings carried out at age 13, 18,23,28 and 33 years (Regime R2) .

A site index of 29 was adopted as the average site index for the plantation and this was used when calculating the expected yield of sawlogs.

5- The production of sawlogs from the plantation was based on the assumption that the site was uniform in soil fertility,topography and growth potential having an average site index of 29.

6. The appropriate criteria for evaluating the profitability of the plantation development programme from the Queensland Department of Forestry viewpoint was assumed to be Net discounted revenue, while the Net Social Benefit was examined from the national viewpoint. The appropriate rate of discount for use in the social cost-benefit analysis was assumed to be the social rate of time preference while for the Department's viewpoint the average real long-term bond rate between 1959 and 1968 was used. Both rates were identical at 5 per cent.

7. Sawlogs produced by the plantation development programme were assumed to be sold to a sawmill within the region. The sawntimber was subsequently also sold within the Rockhampton region replacing sawntimber which would have to be imported.

8. The real cost of employing people in the plantation was assumed to be the actual wage rates paid. These wages were assumed to represent the marginal productivity of

labour under full employment conditions and were expected to remain constant over time.

10. For the social cost-benefit analysis, the "most likeky" shadow price of sawntimber produced from the plantation was assumed to be the landed price in the Rockhampton market of sawn Douglas fir imported from the United States. The "likely" shadow price was assumed to be the landed price of Pinus radiata sawntimber in the Rockhampton market imported from New Zealand. The importation of sawn coniferous timber from these sources is expected to continue until the turn of the century at least. The lower limit to the shadow price was assumed to be the price of indigenous sawntimber in the Rockhampton market.

11. The Pinus caribaea plantation at Byfield was expected to meet some of the anticipated deficit between local indigenous production and consumption. For this to be achieved the mechanical and physical properties of the sawn Pinus caribaea will have to meet the standard requirements for softwood used as a construction material and other domestic purposes.

10.2 Recommendations and further research

An assessment of the environmental effects of the plantation was outside the scope of this study. Further investigations would be necessary to quantify the associated environmental costs and benefits resulting from the plantation through its impacts on local recreation, water quality, soil erosion, wildlife conservation and other non-economic benefits or costs.

The locally grown stands of Pinus caribaea are still relatively young; its eventual growth and productivity and mechanical and physical end use properties are still being determined. Further research is necessary in the general area of the utilisation, processing and marketing of the end products of this species. Such research would be invaluable for determining the best uses of Pinus caribaea and enabling it to substitute for other imported softwood species and locally available hardwoods.

Further research is also required into the use of fertilisers, site preparation and tree breeding in order to improve the productivity and quality of Pinus caribaea to enable it to compete better with other forest products.

The Rockhampton region appears likely to become an important industrial centre in the future. As Rockhampton is currently a relatively isolated urban centre, transportation costs are a critical factor in the pricing of sawntimber especially when it has to be imported either from other parts of Queensland or from overseas. A more detailed study of the regional impact of the plantation development programme at Byfield than was able to be undertaken in this study would be essential for those undertaking the land use and development planning of the region.

10.3 Conclusions

This study was carried out in two parts. The first part examined the profitability of developing and running the Bowenia plantation from the viewpoint of the initiating organisation namely the Queensland Department of Forestry. The second part examined the social benefits and costs of developing the plantation from the national viewpoint and where most of the output was assumed to replace future imports of sawntimber.

10.3.1 Cost benefit analysis from the Department's viewpoint

The economic worth of developing and running the plantation from the Department's viewpoint was discussed in chapter 7. The NDR of the project indicated that the plantation managed under regime R1 was a financially sound investment under the cost and price assumptions studied when an interest rate of 5 per cent was used. Under the most optimistic price assumption PL4 the internal rate of return for regime R1 rose to just over 7 per cent.

The costing of the plantation development operations was based on the labour intensive methods used by the Department in 1974 which were expensive in both unit costs and overheads. Consequently, the total costs of operations could be reduced by the introduction of mechanisation into planting , pruning, and thinning operations. As each of these operations is labour intensive machanisation is likely to reduce both the direct unit costs and the overhead costs. To examine the effect of this total costs were reduced by 1 per cent per annum which resulted in the Net discounted revenue increasing by $100 per hectare which substantially increased the worthwileness of the project.

The cost of importing sawntimber into Australia has increased very sharply in recent years. The main reason for this increase was the substantial increase in the rate of inflation in the two countries supplying softwood sawntimber to the Australian market (namely the United States and New Zealand). At the same time, freight rates between these countries and Australia increased substantially. It seems likely that once the present depressed world markets begin to recover these trends will strengthen. If they do continue in real terms there will be added scope for the price of domestically produced Pinus caribaea to rise thus allowing stumpage values to rise at least in line with the assumption underlying price level PL4. The possibility of lowering establishment costs over time as the project expands, and of achieving higher real price levels tend to make the project a much more attractive investment with an internal rate of return of between 7 and 8 per cent.

10.3.2 Social analysis from the nation's viewpoint

The NSB for the social cost-benefit analysis of the project assuming a 5 per cent social rate of time preference was $895 per hectare for regime R1 and price assumption A (the price at which sawn Pinus caribaea from the plantation was assumed to compete with imported sawn Douglas fir). If the future price of imported sawntimber continues to increase in real terms at its recent rate discussed in chapter 5 then the project will be economically desirable even under price assumption C (the shadow price of indigenous sawntimber). The Net Social Benefit for regime Rl at this price level was $31 per hectare . Under regime R2 where Pinus caribaea sawntimber merely continues to receive the prevailing domestic Rockhampton price, the project would incurs a net social loss of $7 per hectare in real terms.

The overall results of the study indicate that from the national viewpoint, the rate of return is over 5 per cent on capital invested although it is very sensitive to changes in stumpage prices and the shadow price of capital.

From the national viewpoint, the present rate of development of the plantation would be able to reduce the annual sawntimber import bill by some $4,000,000 in terms of 1974 constant prices by the year 2014 . Although balance of payments aspects have not been of major concern in recent years the figures presented do indicate the efficiency of this plantation development proposals in saving future imports. However in general terms, import replacement only becomes of national benefit if balance of payments difficulties become severe.

Plantation development programmes also contribute towards decentralisation by increasing the economic activity in rural areas through the impact of both backward and forward linkages. The effects of these linkages are diverse and cover such aspects as the provision of services, the creation of new job opportunities within the processing industries such as sawmilling, logging and transportation which have to be established as a result of undertaking the plantation.

The effect of the establishment of a forestry plantation in a particular region have been described in chapter 1. The Bowenia plantation clearly makes an important contribution to the immediate region by providing employment for 30 to 40 people annually (under the present rate of development). The number of job opportunities is expected to increase even further as the plantation approaches the sustained yield stage. The linkages between forestry, logging and sawmilling will create further scope for employment. At the sustained yield stage , this employment is likely to rise to at least 600 people under the assumption made earlier(LEWIS,1967).

10.4 Summary

The results obtained from the analysis for the Queensland Department of Forestry and national level are very encouraging for the Bowenia plantation under current management practices. However, in the foreseeable future, the likely increases in the price of sawntimber and the potential reduction in real costs through mechanisation in planting, pruning and thinning indicate that the Bowenia plantation will be a financially secure investment. Further investigation into the improvement of silvicultural techniques will be necessary because the results show that the Net discounted revenue of the regime R1 was higher than that of the regime R2.

The expansion of the Bowenia plantation is not only a sound investment in terms of resource allocation in the region it also generates job opportunity if there is a continued industrial development in the region. The future achievement of the optimum economic results from the plantation also depend on the ability of <u>Pinus caribaea</u> to substitute effectively for imported sawntimber notably Douglas fir.

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Appendix 2.1

Forecast of population in Central Queensland

Year	Fitzroy Region	Central West Region	Mackay
1971	114500	15200	65200
1975	127100	12100	69400
1980	139500	10700	76100
1985	152600	9600	83400
1990	157800	9000	9100
1995	169300	9000	98900
2000	182900	9000	107300

Source: Coordinator General's Department,1974.

Appendix 2.2

Queensland Department of Forestry forecast

per capita consumption of forest products

Products	1972 (m3)	2010 (m3)
Sawnwood and sleepers	1.04	0.83
Paper and paper board	0.44	0.79
Particle board and plywood	0.031	0.062
Round, fencing and mining timbers	0.027	0.020

Source: Softwood Forestry Inquiry, Maryborough,March 1975.

Appendix 3.1

Site index Area by planting year of Pinus caribaea.

Planting	Area of site index in hectares								Total
Year	-21	21	24	27	30	33	35	39	-
1952/53	-	0.13	0.93	4.09	5.2	1.05	-	-	11.4
1953/54	-	-	-	3.72	2.83	1.86	2.83	0.13	11.4
1954/55	1.38	2.30	5.02	11.65	17.00	17.36	8.34	0.60	63.65
1955/56	7.52	10.56	18.54	14.61	9.27	5.10	0.24	-	65.93
1956/57	-	3.00	6.92	11.57	12.40	5.74	6.76	1.41	47.80
1957/58	0.48	0.48	9.91	16.31	10.08	7.61	2.23	-	47.10
1958/59	0.16	1.58	8.34	23.80	31.94	13.30	2.43	-	81.55
1959/60	-	0.36	3.52	15.46	31.61	37.24	25.23	10.24	124.66
1960/61	5.35	15.34	36.95	41.62	32.15	17.33	9.63	2.67	161.00
1961/62	11.78	25.06	48.50	46.72	34.25	7.57	0.80	-	174.70
1962/63	7.61	44.67	35.00	47.28	27.90	9.71	3.31	-	175.50
1963/64	5.06	25.22	32.06	27.53	25.80	14.90	2.50	-	134.00
1964/65	6.11	19.02	36.27	41.86	35.14	12.06	3.00	0.20	153.66

Appendix 3.2

Site index Area by planting year of Pinus elliottii

Planting	Area of site indix in hectares					Total
year	-15	15	18	21	24	27	
1949/50	1.98	5.91	9.59	3.20	1.94	-	22.62
1950/51	2.02	10.80	14.37	14.45	3.80	0.48	45.90
1951/52	1.21	15.50	38.62	6.03	0.85	-	62.21
1952/53	4.65	16.03	36.43	21.05	10.72	-	88.89
1953/54	3.40	46.76	51.61	18.66	8.01	-	128.45
1954/55	4.90	21.13	42.39	26.47	5.14	-	100.93
1955/56	1.01	5.95	49.06	22.30	2.39	-	80.70
1956/57	8.90	36.50	40.57	15.82	1.21	-	103.00
1957/58	7.65	31.82	28.70	6.72	0.60	-	75.5
1958/59	15.79	45.79	34.70	8.66	2.02	-	107.00
1959/60	14.98	37.37	24.37	2.14	1.74	0.16	80.70
1960/61	4.60	2.46	3.84	6.15	1.78	-	18.80
1961/62	-	-	-	0.70	0.63	-	1.33
1962/63	-	-	1.45	3.38	1.70	0.24	6.67
1963/64	-	1.25	5.87	3.68	-	-	10.80

Appendix 3.3

Maintenance of firebreaks and road system

in the Bowenia plantation

1949/50-1973/74

Items	width	length
-	(metres)	(kilometres)
Fire maintained	8	4.5
Mechanically maintained	60	10.8
Fire maintained	40	13.3
Mechanically maintained	30	14.5
Fire maintained	30	4.0
Fire maintained emergency	30	17.5
Mechanically maintained grade	10	21.5
Mechanically slashed	10	95.0
Access truck	10	100.0
Buffer line	10	12.5
Mechanically graded	15	2.5
Mechanically slashed	15	23.5
Fireroad mechanically maintained	15	5.0
Road graded	30	14.5
Road slashed	30	10.0
Road graded	60	11.5
Road slashed	60	17.0
Road graded	8	5.0

Source: Bowenia forestry office,1974

Appendix 6.1

Direct costs of primary forest operations in the Bowenia plantation, 1973/1974

ITEMS	Wage	Materials
-	($/ha)	($/ha)
Clearing site	2.50	-
Ploughing	6.35	-
Plants at site	8.40	-
Planting	45.00	-
Fertilizing	13.50	15.30
Tending		
1st year	5.25	-
2nd year	14.00	-
3rd year	9.90	7.40
Roading & Firebreaks	60.00	-
Nursery costs		
Tubing	0.27	-
Tube costs	0.035	-
Pruning I		
Marking	15.30	1.70
Pruning	21.50	2.50
Pruning II		
Marking	10.30	1.50
Pruning	25.30	1.60
Pruning III	35.50	1.60
Surveys	5.45	-

Source: Forestry sub-district of Rockhampton,1974.

APPENDIX 6.2

Estimated costs and Economic life of Equipment

Over 10 years life	1974 Prices
1 office	\$10,000
1 8 men barracks	\$8,000
1 cottage	\$8,000
2 Fire towers a 8000	\$16,000
1 Garage/Workshop	\$15,000
1 storeroom	\$5,000
10 years life	
1 Cobras hand drill	\$2,000
2 ploughs	\$5,000
1 Disc harrow	\$600
3 Fire tankers \$ equipment	\$48,000
1 Ripper	\$500
1 Rotary slasher	\$2,500
8 years life	
1 4 wheel drive tractor	\$28,000
1 Crawler tractir	\$50,000
2 2 wheel drive tractors	\$54,000
5 years life	
2 light utility	\$4,600
1 Tip truck	\$6,000
2 Flat top trucks	\$16,600
1 4 Wheel drive(Land Rover)	\$3,700
1 Tip trucks (12Tonnes)	\$18,000
2 years life	
7 Chain saws	\$1610

APPENDIX 6.3

Purchases Schedule of Equipment For the Bowenia plantation

(Total area = 8,000 hectares)

Years	
1	1 Tip Truck
	1 4 wheel drive
	2 Chain saws
	1 Disc harrow
	2 Ploughs
	1 Cobras hand drills
	1 Fire tanker $ Equipment
	1 Ripper
	1 4 wheel drive tractor
	1 Crawler tractor D15
3	3 Chain saws
4	1 Flat top truck
	1 Fire tanker
	1 Rotary slasher
5	1 Light Utility
	1 Tip truck
	1 Four wheel drive
	4 Chain saws
9	1 Flat top truck (6 tonnes)
	1 4 wheel drive tractor

	1 Crawler tractor
	7 Chain saws
10	1 Light Utility
	1 Tip truck
11	1 Tip truck
	1 4 wheel drive
	1 Disc harrow
	2 Ploughs
	1 Fire tanker
	1 Ripper
12	7 Chain saws
	1 2 wheel drive tractor (65HP)
14	1 Rotary slasher
	1 Fire tanker
	1 Flat top truck (6 tonnes)
15	1 Light Utility
	1 Tip truck
	1 Flat top truck (new)
	7 Chain saws
	1 2 wheel drive tractor (65HP new)
16	1 Tip truck
	1 4 wheel drive

17	1 4 wheel drive tractor
	1 Crawler tractor D15
18	7 Chain saws
20	1 2 wheel drive tractor (65HP)
	1 Light Utility
	1 Tip truck
	1 Flat top truck
21	7 Chain saws
	1 Tip truck
	1 4 wheel drive
	1 Disc harrow
	2 Ploughs
	1 Fire tanker
	1 Ripper
23	1 2 wheel drive tractor (65HP)
24	1 Rotary slasher
	1 Fire tanker
	7 Chain saws
25	1 Fire tanker (new)
	1 4 wheel drive tractor
	1 Crawler tractor D15
	1 Light Utility
	1 Tip truck

	1 Flat top truck
	1 Light Utility (new)
	1 Tip truck (12 tonnes)
26	1 Tip truck
	1 4 wheel drive
27	7 Chain saws
28	1 2 wheel drive tractor (65HP)
30	2 Light Utility
	1 Tip truck
	1 Flat top truck
	7 Chain saws
	1 Tip truck (12 tonnes)
31	1 Disc harrow
	2 Ploughs
	1 Fire tanker
	1 Ripper
	1 2 wheel drive tractor (65HP)
	1 Tip truck
	1 4 wheel drive
33	1 4 wheel drive tractor
	1 Crawler tractor
	7 Chain saws
34	1 Rotary slasher

	1 Fire Tanker
35	1 Fire tanker
	2 Light Utility
	1 Tip truck
	1 Flat top truck
	1 Tip truck (12 tonnes)
36	1 2 wheel drive tractor (65HP)
	1 Tip truck
	1 4 wheel drive
	7 Chain saws
39	1 2 wheel drive tractor
	7 Chain saws
40	2 Light Utility
	1 Tip truck
	1 Flat top truck
	1 Tip truck (12 tonnes)

APPENDIX 6.4

Annual running costs of motor vehicles and tractors in the Bowenia plantation

Make & Model	Average Annual	Fuel Costs	Oil Costs	Tyres Costs	Maintenance & Repair Costs
-	Hours	Per Hour	Per Hour	Per Hour	Per hour
Crawler Tractor:-					
International TD15B	890.2	$0.62	$0.23	-	$9.85
Rubber-Tyred Tractors:-					
County 4	1099.7	$0.22	$0.16	$0.08	$2.29
David Brown 1200	625.0	$0.24	$0.26	$0.02	$3.63
Fire tanker:-	Days	Per Day	Per Day	Per Day	Per Day
Bedford RLHC	103	$0.71	$0.18	$0.60	$16.80
Motor Vehicules:-	Kilometres	Per Km	Per Km	Per Km	Per Km
Willys Overlander	15556.0	0.05	$0.02	$0.02	$0.24
Land Rover 109	13662	$0.05	$0.02	$0.02	$0.11
Ford D300	11207.0	$0.08	$0.02	$0.02	$0.21
Ford D600	12413.0	$0.10	$0.02	$0.02	$0.27
International D1310	12502.0	$0.10	$0.02	$0.02	$0.13
Ford F250	6321.0	$0.06	$0.02	$0.02	$0.13
Datsun Patrol	12337.0	$0.03	$0.02	$0.02	$0.14

Source : Queensland Department of Forestry, 1975.